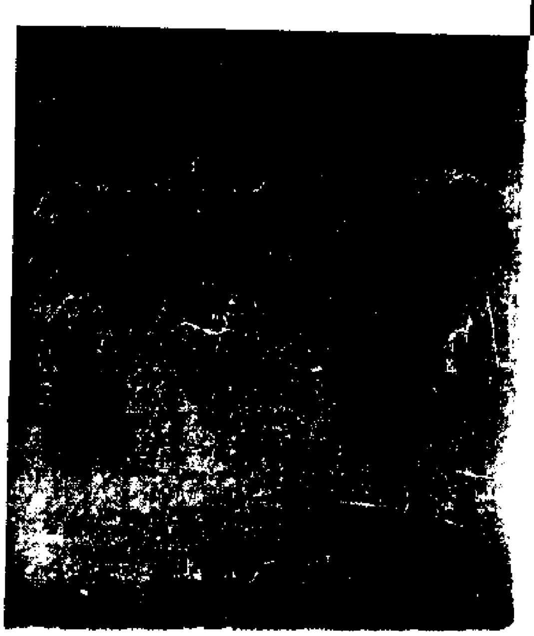
UNIVERSITY OF MIAMI SEA GRANT PROGRAM

(Economics)

Costs and Benefits of the Abatement of Pollution of Biscayne Bay, Miami, Florida

RUTH MERCEDES SAMPEDRO



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Costs and Benefits of the Abatement of Pollution of Biscayne Bay, Miami, Florida

Ruth Mercedes Sampedro

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PREFACE

The Sea Grant Colleges Program was created in 1966 to stimulate research, instruction, and extension of knowledge of marine resources of the United States. In 1969, the Sea Grant Program was established at the University of Miami.

The outstanding success of the Land Grant Colleges Program, which in 100 years has brought the United States to its current superior position in agricultural production, helped initiate the Sea Grant concept. This concept has three primary objectives: to promote excellence in education and training, research, and information services in sea related university activities including science, law, social science, engineering and business faculties. The successful accomplishment of these objectives, it is believed, will result in practical contribution to marine oriented industries and government and will, in addition, protect and preserve the environment for the benefit of all.

With these objectives, this series of Sea Grant Technical Bulletins is intended to convey useful studies quickly to the marine communities interested in resource development without awaiting more formal publication.

While the responsibility for administration of the Sea Grant Program rests with the National Oceanic and Atmospheric Administration of the Department of Commerce, the responsibility for financing the Program is shared by Federal, industrial and University contribution. This study, Costs and Benefits of the Abatement of Pollution of Biscayne Bay, Miami, Florida, is published as a part of the Sea Grant Program and was made possible by Sea Grant projects in Economics for Ocean Resource Management.

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Chapter 1 - INTRODUCTION

The third session of the Conference in the Matter of the Pollution of the Navigable Waters of Dade County, Florida, and Tributaries, Embayments, and Coastal Waters, was held July 2-3, 1971, the purpose of which was to "bring together the State water pollution control agency, representatives of the Environmental Protection Agency, and other interested parties to review the existing situation, and the progress which has been made, to lay a basis for future action...., (and) to take any indicated remedial action under the State and local law."[1]

The conclusions and recommendations to come out of this conference were based on the fact that pollution of the waters of Dade County is occurring; and is endangering the general health and welfare of its persons. If this is the case, the pollution of these waters is subject to abatement under the Federal Water Pollution Control Act. (This act was amended and recently has passed both the House and the Senate. It "(d)eclares as national goals the elimination of the discharge of pollutants into the waters of the United States by 1985 and the achievement wherever attainable of an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides that recreation in and on the water be achieved by 1981."[2])

Measures taken to abate pollution of Dade's waters were termed

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[1] Third session of the Conference in the Matter of the Pollution of the Navigable Waters of Dade County, Florida, and Tributaries, Embayments, and Coastal Waters, (Athens, Ga.: Environmental Protection Agency, 1971), p.7.

[2] Senate Bill S 2770. Mr. Muskie, et al.; October 28, 1971.

"inadequate" by the conference, substitution of discharge of untreated sewage to the ocean for discharge of treated sewage to the inland canal system was deemed "retrogressive", the elimination of existing septic tanks and control of new septic tanks was considered "unsatisfactory", and many minor wastewater treatment plants were found to violate State and County standards.[3]

In general, the conferees recommended the following:

"1. By January 1, 1974, a regional collection and treatment system to serve all waste sources in Dade County shall be in operation. This system shall provide secondary treatment and disinfection with a biochemical oxygen demand and suspended solids removal efficiency of not less than 90 percent; and shall provide for discharge of such treated effluent to the ocean at the edge of the Gulf Stream, except where alternative disposal of such effluents may be acceptable as discussed in the following recommendation.

"2. The Metropolitan Dade County Commission shall present to the conferees, through the State of Florida, a completed interim plan for abatement of pollution from all waste sources in Dade County by November 1, 1971.[4] This plan shall be in a form

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[3] Third session of the Conference in the Matter of the Pollution of the Navigable Waters of Dade County, Florida, and Tributaries, Embayments, and Coastal Waters, (Athens, Ga.: Environmental Protection Agency, 1971) p.7.

[4] See Greeley and Hansen, and Connell Associates, Inc., Interim Water Quality Management Plan for Metropolitan Dade County, prepared for the Metropolitan Dade County Planning Department.

acceptable for certification under applicable State and Federal laws and regulations. Further, the plan shall include: a) A time schedule for construction to meet the deadlines established by the Federal-State conferees; b) an equitable arrangement for financing; c) a schedule for the preparation of preliminary plans and specifications, preparation of final plans and specifications, award of contracts, and initiation and operation of remedial facilities; d) consideration of alternate effluent disposal schemes for the southern portion of Dade County, giving special attention to studies conducted and reported to the conferees by the City of Homestead; and e) a conceptual plan for the reuse of treated waste effluents throughout the county. The County should also encourage public and private utilities to conduct research in the area of water recharge and reuse.

" 3. The cessation of all waste discharges into the inland canal system of Dade County shall be accomplished as rapidly as possible but not later than January 1, 1973.

" 4. Dade County shall enforce the existing regulations concerning restrictions on septic tanks until the study referred to in conclusion number five has been completed and new regulations are promulgated.

" 5. Additional waste discharges to Lower Biscayne Bay, including the Biscayne National Monument, and its tributaries shall be prohibited. This same prohibition shall apply to discharges to canals in Dade County which drain to the Everglades National Park. Removal of existing municipal and industrial waste discharges from these waters shall be accomplished as rapidly as possible but not later than January 1, 1974.

" 6. All wastes from vessels used as domiciles or business establishments shall be discharged to onshore facilities. The County shall present to the conferees by November 1, 1971, a plan for meeting this requirement. The County's plan must include an implementation schedule for meeting deadlines established by the Federal vessel sanitation standards when promulgated.

" 7. Until such time as the minor waste water treatment plants in the county are connected to an acceptable regional collection and treatment system, they shall meet the following requirements:

a) Provide for leveling peak flows;

b) Provide multiple level digestion outlets;

c) Provide drains on all tanks to facilitate cleaning;

d) Provide and maintain reliable chlorine dosing equipment;

e) Provide and maintain flow meters;

f) Prohibit submersible pumps for feeding pressure filters;

g) Have licensed operators or be operated by licensed consultants; and

h) Collect and report operational data to the Florida Department of Air and Water Pollution Control. The Dade County Pollution Control Officer shall continue to monitor the operation of these plants and enforce these requirements as necessary.

" 8. The Environmental Protection Agency shall complete its inventory and analyses of industrial sources and report its findings to the conferees and the Dade County Pollution Control Officer by September 1, 1971. The Dade County Pollution Control Officer shall immediately act on reported violations of State and County standards and report to the conferees his progress in correcting these violations by November 1, 1971.

" 9. The technical committee established pursuant to the recommendations of the first session of the conference shall report to the conferees its progress and future plans for developing a regional water quality management plan by November 1, 1971.

"10. The Environmental Protection Agency shall conduct studies of existing ocean outfalls and the coastal zone to develop and recommend detailed ocean disposal criteria. Preliminary criteria shall be reported to the conferees by July 1, 1972.

" 11. Dade County shall provide plans for the immediate installation of primary treatment on the North Dade transmission line to the Florida Department of Air and Water Pollution Control and the Environmental Protection Agency by August 6, 1971 (primary treatment being defined as essentially complete removal of floatable and settleable solids). Also, by August 6, 1971, the Dade County Commission shall show cause to the State and Federal agencies why it cannot renogotiate phase out contracts on plants now providing treatment to continue such treatment at no additional cost to user until the northern regional treatment plant is operational. No future phase out contracts shall be negotiated by the County without prior approval of the conferees."[5]

The Master Plan

In accordance with these recommendations, the Master Plan for Sanitary Sewerage for Metropolitan Dade County, 1961, "a comprehensive plan for pollution abatment", was updated and amended by Greeley and Hansen and Connell Associates, Inc. in a joint venture. In 1970 the Pollution Abatement Planning Program was developed by Metropolitan Dade County to "insure the preparation of a fully developed, comprehensive water quality management plan and pollution abatement program as well as a long and short range water facilities plan."[6] The plan qualifies for federal assistance and complies with the regulations of the Environmental Protection Agency, and divides Dade County into three sewerage districts, each served by a single sewage treatment plant as follows:

a) A North District, with a treatment plant to be constructed near Interama, of ultimate capacity 80 mgd (million gallons per day), and also to serve Miami Beach;

b) A Central District, with the treatment plan at Virginia Key to be enlarged;

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[5] Third session of the Conference in the Matter of the Pollution of the Navigable Waters of Dade County, Florida, and Tributaries, Embayments, and Coastal Waters, (Athens, Ga.: Environmental Protection Agency, 1971), Conclusions 1-11.

[6] Greeley and Hansen, Connell Associates, Inc., "Interim Water Quality Management Plan for Metropolitan Dade County (Miami: Dade Co. Planning Dept., 1972), p.i.

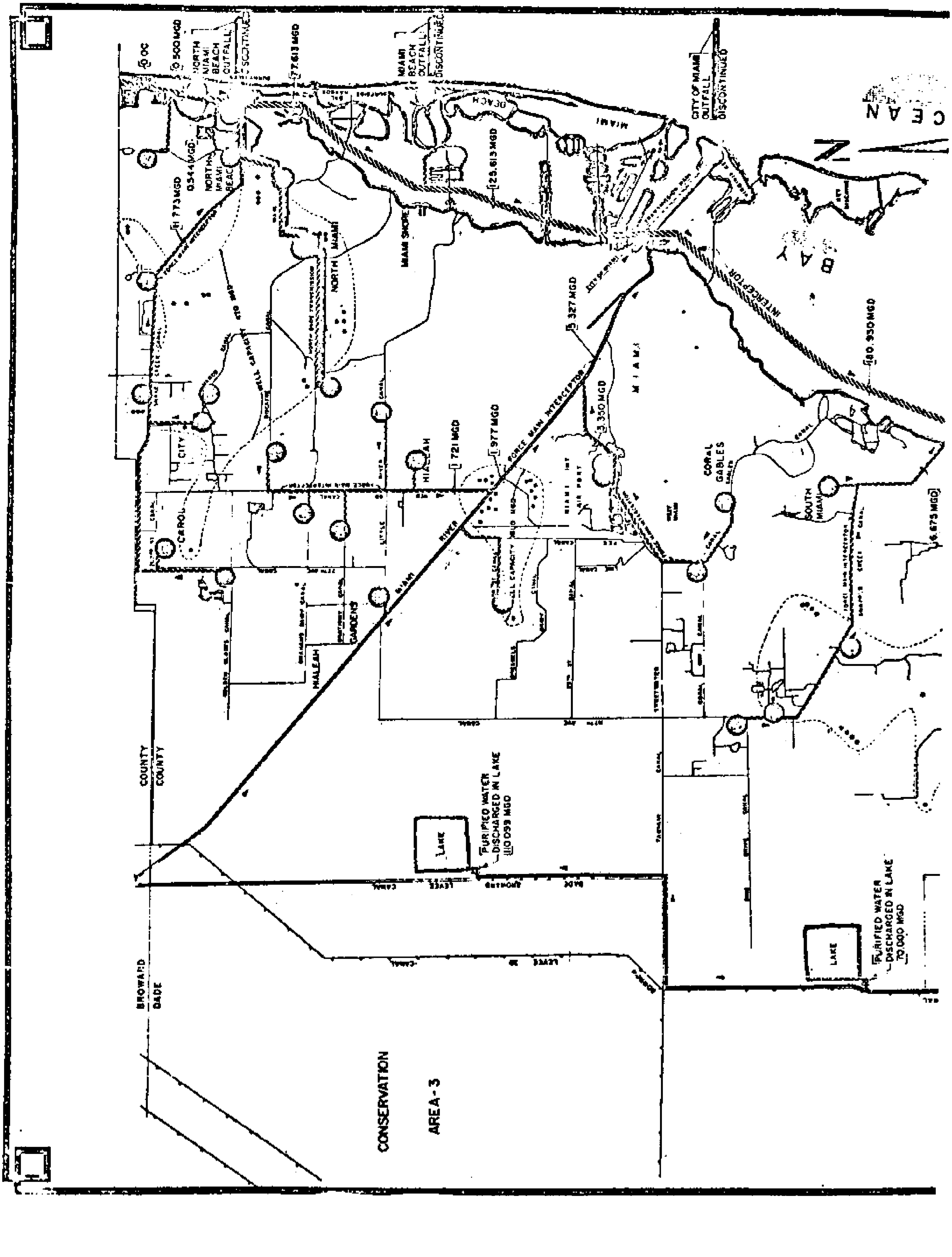
c) A South District, with a treatment plant to be constructed at Black Creek near U.S. Highway 1, of 50 mgd.

All plants will provide secondary treatment and will discharge via outfalls to the Atlantic Ocean. Sewage transmission mains will be constructed to intercept flows of all plants now discharging into canal systems. These plants will be retired or retained according to their ability to provide pretreatment, but all plants will be retired over the next five years and will become pumping stations to the larger plants.

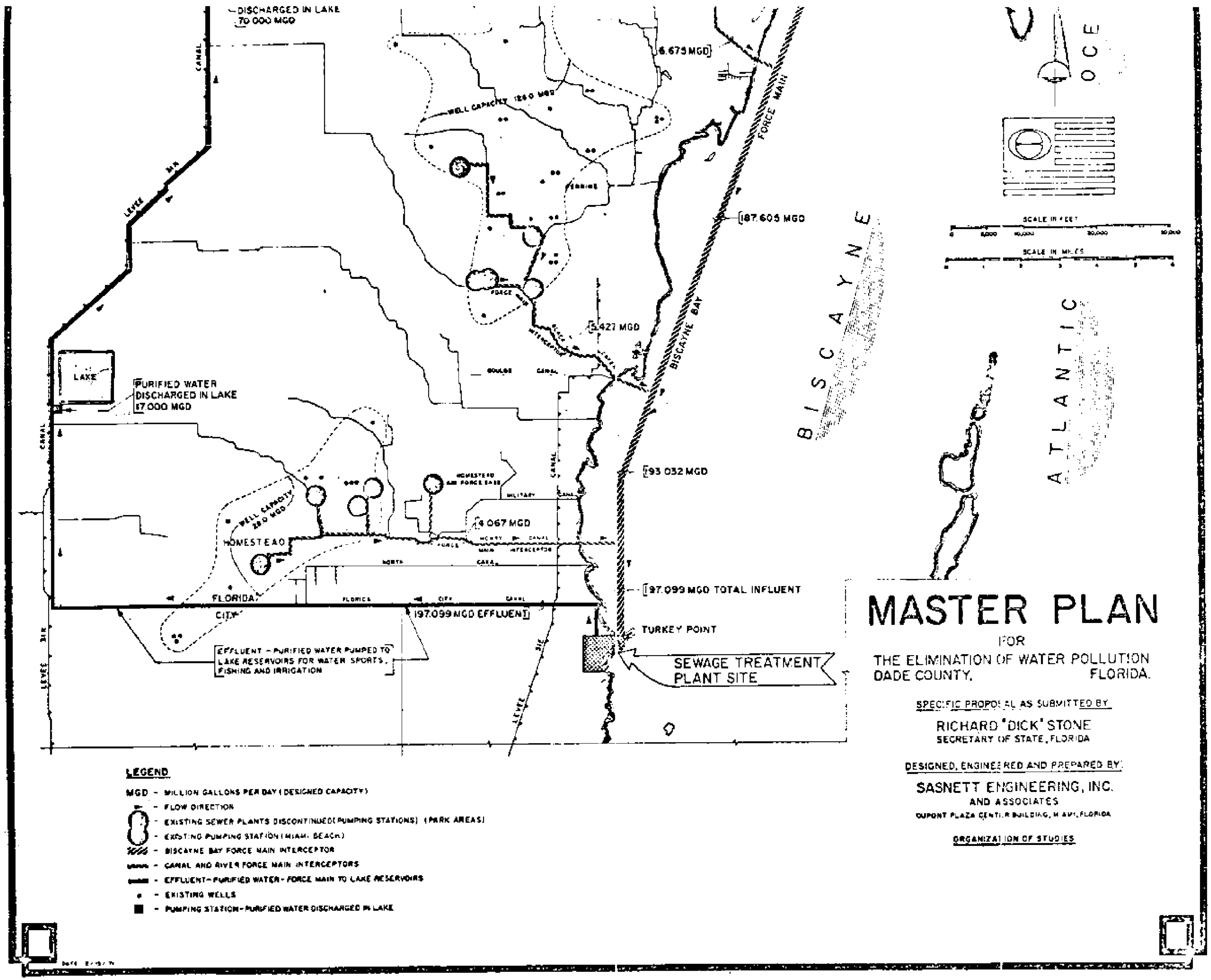
The total construction cost of this system is estimated at $258,296,000 funded out of Federal, State and County sources. This estimate does not include the cost of providing street mains to areas not now sewered, neither industrial nor residential, nor does it include the cost of industrial pretreatment.

The Scope of this Study

As an estimate of the total cost to Dade County of the abatement of pollution of its waters, the above is inadequate from the economist's point of view, especially since cost estimates were not discounted to reflect values today of future cost expenditures. This study is an attempt to arrive at an estimate of the total cost to Dade County of pollution abatement. This cost figure includes capital costs and operating and maintenance costs for municipal sewage plants, costs of providing gravity and transmission lines plus individual household hook-ups to areas not now sewered, cost of treating industrial effluents that are now being discharged into surface waters, and costs of extending and providing more ocean outfalls. These costs will be borne by householders, local industries, and federal and local government, and are discounted at six and twelve percent.



CONSERVATION
AREA-3
BROWARD
DADE
COUNTY
COUNTY
PURIFIED WATER DISCHARGED IN LAKE
LAKE
LAKE
PURIFIED WATER DISCHARGED IN LAKE
70.000 MGD
HIALEAH
GARDENS
CAROL
CITY
MIAMI RIVER
FORCE MAIN INTERCEPTOR
MIAMI SHORES
NORTH MIAMI
NORTH MIAMI BEACH
NORTH MIAMI BEACH OUTFALL DISCONTINUED
MIAMI BEACH OUTFALL DISCONTINUED
CITY OF MIAMI OUTFALL DISCONTINUED
MIAMI
CORAL GABLES
SOUTH MIAMI
INTERCEPTOR
BAY
OCEAN
80.930 MGD
25.613 MGD
77.613 MGD
5.327 MGD
3.350 MGD
1.977 MGD
1.721 MGD
6.675 MGD



DISCHARGED IN LAKE
70 000 MGD
6.675 MGD
WELL CAPACITY 126.0 MGD
FORCE MAIN
187.605 MGD
BISCAYNE BAY
5.427 MGD
BISCAYNE
ATLANTIC
OCE
SCALE IN FEET
SCALE IN MILES
LAKE
PURIFIED WATER
DISCHARGED IN LAKE
17 000 MGD
CANAL
LEVEE
HOMESTEAD AIR FORCE BASE
MILITARY
4.067 MGD
WELL CAPACITY 28.0 MGD
HOMESTEAD
NORTH
FLORIDA
FLORIDA CITY CANAL
CITY
93 032 MGD
97.099 MGD TOTAL INFLUENT
197.099 MGD EFFLUENT
TURKEY POINT
EFFLUENT - PURIFIED WATER PUMPED TO LAKE RESERVOIRS FOR WATER SPORTS, FISHING AND IRRIGATION
SEWAGE TREATMENT PLANT SITE
MASTER PLAN
FOR
THE ELIMINATION OF WATER POLLUTION
DADE COUNTY, FLORIDA.
SPECIFIC PROPOSAL AS SUBMITTED BY
RICHARD "DICK" STONE
SECRETARY OF STATE, FLORIDA
DESIGNED, ENGINEERED AND PREPARED BY:
SASNETT ENGINEERING, INC.
AND ASSOCIATES
DUPONT PLAZA CENTER BUILDING, MIAMI, FLORIDA
ORGANIZATION OF STUDIES
LEGEND
MGD - MILLION GALLONS PER DAY (DESIGNED CAPACITY)
- FLOW DIRECTION
- EXISTING SEWER PLANTS DISCONTINUED (PUMPING STATIONS) (PARK AREAS)
- EXISTING PUMPING STATION (MIAMI BEACH)
- BISCAYNE BAY FORCE MAIN INTERCEPTOR
- CANAL AND RIVER FORCE MAIN INTERCEPTORS
- EFFLUENT - PURIFIED WATER - FORCE MAIN TO LAKE RESERVOIRS
- EXISTING WELLS
- PUMPING STATION - PURIFIED WATER DISCHARGED IN LAKE

This study will also examine some of the benefits that will accrue to Dade County once the environment is able to increase its flow of services. The physical-biological ecosystem and the "services" it provides and society derives from it, (serving as a habitat for marine animals and especially as a nursery for commercial fish, as a place for recreation and relaxation, and in its ability to assimilate and transform degradable wastes, to mention only a few of the services the ecosystem provides), are very much affected by the amount of pollutants discharged into it.

As society reduces its polluting discharges, less stress is placed on the ecosystem and, in general, the flow of services to society increase.

In order for the federal, state, and local governments to be allocating their resources properly, any attempt to reduce polluting discharges must meet at least the following criterion: the value of the increase in the flow of services from the environment caused by the decrease in pollutants must beequal to or greater than the cost of the pollution abatement activity. Because of the difficulties of measuring the value of many of the things the environment provides (i.e. many recreational activities, a cool, quiet, wooded area, etc.), it is very difficult to know when this criterion is met. The purpose of this study is to see if the Dade County pollution abatement plan described above meets it. The total cost of the plan will be measured and compared with a partial measure of its benefits.

Chapter 2 - SOURCES OF POLLUTION IN STUDY AREA

There are four major sources of polluted waters entering Biscayne Bay: 1) municipal and domestic wastes, 2) industrial discharges, 3) natural runoff after precipitation, and 4) municipal and industrial wastes, plus rural runoff from areas as far North as Lake Okeechobee. The first two sources of pollution have been quantified recently by the Environmental Protection Agency, the last two can be estimated by measuring the amount of biochemical oxygen demand (BOD) unaccounted for.

What is pollution?

Water pollution can be described as the addition to water of substances which deteriorate the quality of the water.[7] These substances can either be living or nonliving, organic or inorganic, degradable or nondegradable.

Degradable wastes, and most of our municipal wastes are degradable wastes, are wastes that are decomposed by interaction with air and water, and as a consequence of photosynthesis, and will not be offensive unless the receiving waters are overloaded. When this happens, degradation will proceed unaerobically, releasing hydrogen sulfide and other gases. This is the case when the estuaries, embayments, and diluting waters have insufficient capacity to assimilate the amount of BOD being discharged into the physical system.

BOD (biochemical oxygen demand) measures degradable wastes in

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[7] Amos Turk, Jonathan Turk, and Janet Wittes, Ecology, Pollution, Environment, (Philadelphia: W.B. Saunders and Co., 1972).

terms of the oxygen used in decomposing the waste at 20° C. during a five day incubation period, and it is used as a measure of the amount of polluting substances entering the water. The amount of BOD demanded by the decomposition of the waste and the amount of oxygen restored determines the level of dissolved oxygen (DO) which is a measure of water quality. Toxicity, estimated with bacteria counts; turbidity, measured in terms of total suspended solids (TSS); and changes influencing marine life, such as PH, temperature, and salinity, are other measures of water quality.

Industrial wastes contain inorganic or nondegradable wastes. E.P.A. found industrial wastes in Dade County to contain "toxic substances, heavy metals, oil and petroleum derivatives, acids, alkalies, suspended solids and oxygen-demanding materials."[8] Inorganic chemicals may be toxic or corrosive, and impart foul odors, taste, and color to receiving waters. Suspended solids usually settle out only after a time, (although colloidal material does not) and cause turbidity, making the water cloudy and unattractive, and possibly damaging fish life and inhibiting algae growth.

Municipal Sewage

The waste source inventory conducted by E.P.A. in 1971, surveyed seventy-six wastewater treatment plants to determine treatment efficiency, the amount of bacterial disinfection, and to measure loads of major pollutants.

Some plants achieve a 90% removal efficiency for both BOD and TSS,

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[8] Environmental Protection Agency, Report of Waste Source Inventory and Evaluation, Dade County, Florida (Athens, Ga.: E.PA., 1971), p.11.

others only a 90% efficiency in one, and some did not achieve 90% removal efficiency of either BOD or of TSS.[9]

Wastewater treatment plants contribute the following loads in effluents to Dade County waters:

North District

Snake Creek drainage area (includes the Carol City Canals, Oleta River, and the 77th Avenue Canal): 7.04 mgd, 1,622 lbs/day BOD, 1,616 lbs/day TSS.

Biscayne Canal and Little River drainage area (includes the 138th Street Canal): 1.142 mgd, 366 lbs/day BOD, 407 lbs/day TSS.

Central District

Miami River drainage area (includes FEC Canal and the Dressels Dairy Canal): 60 mgd, 155 lbs/day BOD, 292 lbs/day TSS.

Coral Gables Waterway drainage area (includes the Tamiami Canal): 2.62 mgd, 267 lbs/day BOD, 588 lbs/day TSS.

Snapper Creek Canal drainage area (includes part of Federal Canal): 5.986 mgd, 1,824 lbs/day BOD, 2,303 lbs/day TSS.

South District

Black Creek Canal drainage area (includes Bell-Aire Canal and part of Federal Canal): 3.53 mgd, 862 lbs/day BOD, 2,270 lbs/day TSS.

South Bay drainage area (includes Military Canal and C-103 Canal: 3.21 mgd, 586 lbs/day BOD 989 lbs/day TSS.

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[9] Ibid, pp. 8-9.

Atlantic Ocean

Atlantic Ocean and Biscayne Canal drainage area: 77.1 mgd, 54,175 lbs/day BOD, 48,588 lbs/day TSS.[10]

Unsewered Areas

The wastewater treatment plants in operation today do not take care of 100% of the domestic sewage. In Dade County, 40.3% of all occupied units do not have sewer service. This represents 59.86 million gallons per day[11] of domestic sewage being discharged, through septic tanks and other means of disposal, to ground waters. Sewer lines and individual hook-ups will have to be provided to these households.

Industry

In analyzing 36 unsewered industries, E.P.A. estimated that 7,240 lbs. BOD were being discharged daily into Dade County waters.[12] Some of these industries will be required to provide pre-treatment of their effluents and a connection to the city sewer system. Of fifteen industries discharging to surface waters, five already provide some treatment, and of the remaining ten, eight are located at the Miami International Airport where a collection system will be constructed soon.

Summary

To comply with the recommendations of E.P.A. will therefore require

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10 *Ibid*, p. 10.

11 At an estimate of 100 gallons/person/day; data provided courtesy of the Dade County Community Improvement Program.

12 Lower Florida Estuary Study, *Industrial Waste Survey, Dade County Florida* (Athens, Ga.: Environmental Protection Agency 1971), p. 24.

90% removal efficiency of a total of 59,857 lbs. BOD from 101.23 million gallons per day of municipal sewage and 7,240 lbs. BOD from 1.8 million gallons per day of industrial wastes not yet treated for harmful, non-degradable, effluents by January 1, 1974; treatment of 59.86 million gallons per day of sewage not yet under the collection system; construction of transmission mains and gravity lines to areas not now sewered; and construction of ocean outfalls to carry discharges to the Gulf Stream by January 1, 1973.

TABLE 1

TOTAL BOD LOADS DISCHARGED INTO DADE COUNTY WATERS

	BOD (lbs/day)	mgd
Municipal Sewage		
North District	1,988	8.2
Central District	2,567	9.2
South District	1,488	6.7
Atlantic Ocean	54,175	77.1
Unsewered Areas	-	59.9
Unsewered Industries	7,240	1.8
Total		162.9

Chapter 3 - POLLUTION LEVELS IN BISCAYNE BAY

The BOD loads presented above, plus pollution loads from areas to the North, runoff from rural areas and causeways and bridges, and effluent loads from unsewered marinas, eventually enter Biscayne Bay. This causes water quality, as measured by dissolved oxygen levels, to deteriorate.

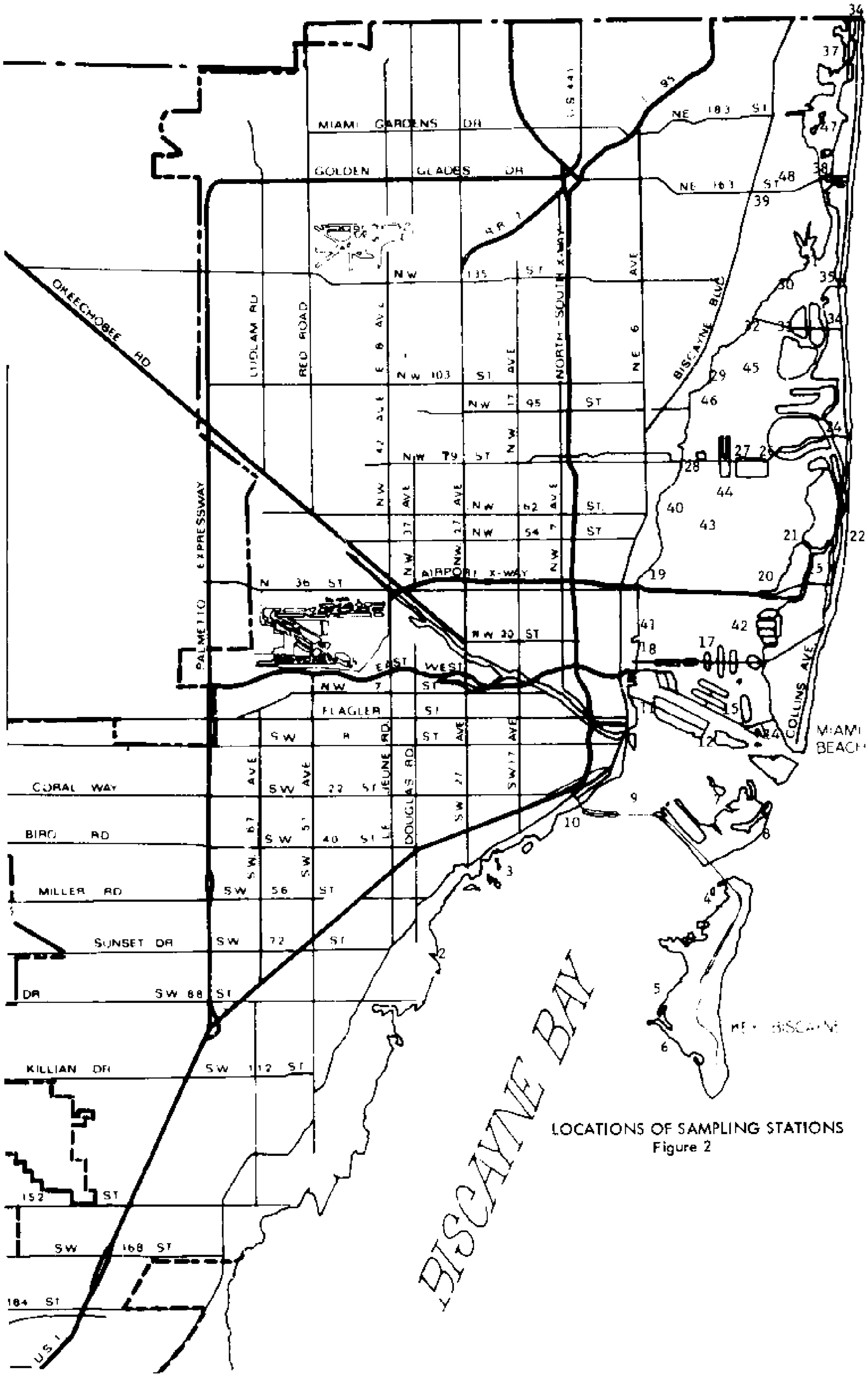
There is a direct relationship between BOD loads and dissolved oxygen levels that can be determined mathematically and can be used to predict changes in dissolved oxygen levels. However, the rate of reaeration of the waters, which is dependent upon the rate of flow, the temperature of the water, the amount of organic living matter present, and other variables, must be known.

It is therefore diffucult to predict by how much dissolved oxygen levels in the bay will rise by reduced BOD loads in waters leading to the bay, but we can be assured they will rise by some amount.

Sampling data from Biscayne Bay waters are presented in Tables 2 and 3. Table 2 compares the summer months of 1971 and 1972. Water quality has improved through the efforts of pollution authorities.

To read the table it is helpful to know that the upper limit on MPN is 1000. Anything beyond that could be harmful. A high MPN count implies receiving waters are overloaded.

Also, oxygen levels approaching saturation are necessary to maintain a commercial or sports fishery, as well as for swimming and human contact.



LOCATIONS OF SAMPLING STATIONS
Figure 2

TABLE 2
SAMPLING DATA: JUNE, JULY 1971 - JUNE, JULY 1972

STATION 1: GABLES BY THE SEA

	1971		1972	
	June	July	June	July
D.O.	4.8	6.0	6.8	6.4
B.O.D.	1.0	10.4	5.6	3.5
PO4	0.00	0.00	0.56	0.32
MPN	1.8	4.5	350.00	130.00
pH	7.8	7.5	7.6	7.8
TEMP. °F	84.0	86.0	84.0	81.0

STATION 2: GABLES WATERWAY

	1971		1972	
	June	July	June	July
D.O.	4.0	6.0	6.8	6.0
B.O.D.	2.5	4.8	3.5	5.6
PO4	0.32	<0.04	0.56	0.12
MPN	21.0	2.0	240.0	240.0
pH	7.8	7.7	7.7	7.8
TEMP. °F	84.0	86.0	84.0	83.0

STATION 3: DINNER KEY

	1971		1972	
	June	July	June	July
D.O.	4.4	5.2	6.4	3.6
B.O.D.	2.5	6.4	1.4	2.1
PO4	0.00	0.00	0.32	0.12
MPN	70.0	1600.0	1600.0	350.0
pH	7.9	7.8	7.7	8.0
TEMP. °F	85.0	87.0	81.0	84.0

STATION 4: CRANDON MARINA

	1971		1972	
	June	July	June	July
D.O.	4.8	5.2	6.0	4.4
B.O.D.	3.5	6.4	4.9	2.8
PO4	0.00	0.00	0.12	0.12
MPN	33.0	7.8	130.0	1600.0
pH	8.0	7.8	7.9	81.0
TEMP. °F	84.0	88.0	81.0	84.0

Source: Dade County Pollution Control Office

TABLE 2 (Continued)

STATION 5: KEY BISC. YACHT CLUB

	1971		1972	
	June	July	June	July
D.O.	4.0	5.2	6.0	---
B.O.D.	3.2	3.2	2.1	---
PO4	0.00	0.00	0.12	---
MPN	11.0	4.5	33.0	---
pH	7.8	7.9	7.8	---
TEMP. °F	85.0	84.0	81.0	---

STATION 6: M HASTA ISLAND

	1971		1972	
	June	July	June	July
D.O.	7.2	7.2	6.0	6.0
B.O.D.	2.5	5.7	1.4	2.1
PO4	<0.04	<0.04	0.32	0.12
MPN	1.8-	2.0	2.0	4.5
pH	7.5	8.0	7.9	8.2
TEMP. °F	85.0	89.0	82.0	84.0

STATION 7: VIRGINIA KEY (S.T.P. Bay)

	1971		1972	
	June	July	June	July
D.O.	4.0	6.0	8.0	8.0
B.O.D.	1.7	4.2	1.4	4.2
PO4	0.24	<0.04	0.24	1.20
MPN	79.0	7.8	130.0	7.8
pH	8.1	7.9	8.0	8.3
TEMP. °F	83.0	89.0	81.0	85.0

STATION 8: BEAR CUT

	1971		1972	
	June	July	June	July
D.O.	6.0	6.4	6.4	4.0
B.O.D.	1.4	2.8	1.4	3.5
PO4	0.00	0.00	0.24	0.00
MPN	49.0	13.0	13.0	14.0
pH	7.7	7.9	8.0	8.2
TEMP. °F	85.0	90.0	82.0	84.0

Sour ce: Dade County Pollution Control Office

TABLE 2 (Continued

STATION 9: RICKENBACKER CAUSEWAY

	1971		1972	
	June	July	June	July
D.O.	6.4	6.8	6.4	8.0
B.O.D.	1.4	6.4	2.1	2.1
PO4	0.00	0.00	0.32	0.40
MPN	2.0	4.5	33.0	1.8
pH	8.0	8.0	8.1	8.3
TEMP. °F	86.0	86.0	81.0	85.0

STATION 10: RICKENBACKER CAUSEWAY

	1971		1972	
	June	July	June	July
D.O.	8.8	6.4	8.0	6.8
B.O.D.	1.7	3.2	0.7	2.8
PO4	0.00	0.00	0.72	0.32
MPN	2.0	1.8	7.8	14.0
pH	8.2	8.1	8.1	8.3
TEMP. °F	87.0	86.0	81.0	85.0

STATION 11: MIAMARINA

	1971		1972	
	June	July	June	July
D.O.	5.6	7.2	6.4	6.0
B.O.D.	1.7	6.4	2.1	2.8
PO4	0.00	≤0.04	0.32	0.44
MPN	1600.00+	1600.00+	17.0	1600.00
pH	8.1	7.9	8.0	8.2
TEMP. °F	86.0	89.0	81.0	85.0

STATION 12: NEW PORT OF MIAMI

	1971		1972	
	June	July	June	July
D.O.	5.2	5.6	6.4	6.0
B.O.D.	1.7	4.8	1.4	3.5
PO4	0.00	0.00	0.04	0.12
MPN	920.0	240.00	11.0	130.0
pH	8.1	8.0	8.0	8.2
TEMP. °F	86.0	87.0	82.0	85.0

Source: Dade County Pollution Control Office

TABLE 2 (Continued)

STATION 13: MACARTHUR CAUSEWAY

	1971		1972	
	June	July	June	July
D.O.	5.6	5.6	6.8	6.8
B.O.D.	1.0	3.2	2.1	2.8
PO4	0.00	0.12	0.32	0.24
MPN	1.8	2.0	17.0	350.0
pH	8.1	8.0	8.0	8.3
TEMP. °F	85.0	88.0	81.0	85.0

STATION 14: U.S. COAST GUARD

	1971		1972	
	June	July	June	July
D.O.	6.0	5.2	6.8	6.0
B.O.D.	2.1	2.4	3.5	2.8
PO4	0.00	0.00	1.12	0.32
MPN	240.0	1.8	1600.0	79.0
pH	8.1	8.0	7.7	8.3
TEMP. °F	84.0	88.0	81.0	84.0

STATION 15: 23st AND INDIAN CREEK

	1971		1972	
	June	July	June	July
D.O.	4.4	6.0	4.4	3.6
B.O.D.	1.7	5.6	0.7	0.7
PO4	≤0.04	≤0.04	0.44	0.80
MPN	1600.00+	920.0	79.0	1600.0
pH	8.0	8.0	7.9	8.1
TEMP. °F	85.0	89.0	84.0	85.0

STATION 16: VENETIAN CAUSEWAY E.

	1971		1972	
	June	July	June	July
D.O.	5.2	5.6	6.4	6.4
B.O.D.	1.0	7.2	1.4	2.1
PO4	0.12	0.00	0.32	0.12
MPN	920.0	7.8	33.0	49.0
pH	8.0	8.0	7.9	8.3
TEMP. °F	84.0	88.0	82.0	85.0

Source: Dade County Pollution Control Office

TABLE 2 (Continued)

STATION 17: VENETIAN CAUSEWAY M.D.

	1971		1972	
	June	July	June	July
D.O.	9.2	6.0	6.8	6.8
B.O.D.	1.4	5.6	2.1	2.1
PO4	0.00	≤0.04	0.04	0.24
MPN	23.0	220.0	920.0	49.0
pH	7.8	8.1	7.9	8.3
TEMP. °F	85.0	89.0	82.0	85.0

STATION 18: VENETIAN CAUSEWAY W.

	1971		1972	
	June	July	June	July
D.O.	6.0	6.4	6.4	7.6
B.O.D.	1.4	4.8	2.8	2.1
PO4	≤0.04	≤0.04	0.32	0.24
MPN	1600.0	49.0	920.0	350.0
pH	8.0	8.1	7.9	8.4
TEMP. °F	85.0	88.0	82.0	85.0

STATION 19: JULIA TUTTLE CAUSEWAY W.

	1971		1972	
	June	July	June	July
D.O.	5.2	7.2	7.2	5.2
B.O.D.	0.7	6.4	3.2	4.0
PO4	0.00	0.00	0.00	0.64
MPN	130.0	2.0	130.0	6.8
pH	8.0	8.0	8.2	7.9
TEMP. °F	84.0	86.0	82.0	82.0

STATION 20: JULIA TUTTLE CAUSEWAY E.

	1971		1972	
	June	July	June	July
D.O.	4.8	5.2	6.8	6.0
B.O.D.	1.0	5.6	1.6	4.0
PO4	≤0.04	0.00	0.00	0.12
MPN	7.8	7.8	49.0	79.0
pH	8.0	7.9	8.2	7.9
TEMP. °F	84.0	86.0	82.0	83.0

Source: Dade County Pollution Control Office

TABLE 2 (Continued)

STATION 21: N. BAY RD. AND W. 48st

	1971		1972	
	June	July	June	July
D.O.	4.0	4.4	6.0	4.4
B.O.D.	1.0	3.2	1.6	3.2
PO4	0.00	0.00	0.24	0.24
MPN	240.0	4.5	130.0	1600.0
pH	7.9	7.8	8.1	7.9
TEMP. °F	84.0	88.0	83.0	82.0

STATION 22: 4999 PINE TREE DR.

	1971		1972	
	June	July	June	July
D.O.	3.6	4.4	4.8	4.0
B.O.D.	1.0	7.2	3.2	4.0
PO4	0.00	0.12	0.12	0.12
MPN	170.0	4.5	240.00	79.0
pH	7.9	7.8	8.1	7.9
TEMP. °F	86.0	88.0	83.0	82.0

STATION 23: 63rd AND INDIAN CREEK

	1971		1972	
	June	July	June	July
D.O.	5.2	4.0	5.2	4.0
B.O.D.	0.7	3.2	0.8	4.8
PO4	0.12	0.00	0.00	0.24
MPN	1600.0	1600.00	34.0	33.0
pH	8.0	7.8	8.1	7.9
TEMP. °F	85.0	87.0	82.0	82.0

STATION 24: FIRE STATION AND INDIAN CR.

	1971		1972	
	June	July	June	July
D.O.	4.8	4.4	5.6	4.0
B.O.D.	1.0	3.2	0.8	2.4
PO4	0.12	≤0.04	0.00	≤0.04
MPN	1600.00+	1600.00+	1600.00	79.0
pH	8.0	7.8	8.1	80.0
TEMP. °F	85.0	88.0	82.0	82.0

Source: Dade County Pollution Control Office

TABLE 2 (Continued)

STATION 25: 1580 STILLWATER DR.

	1971		1972	
	June	July	June	July
D.O.	5.6	4.8	5.2	3.2
B.O.D.	0.3	6.4	1.6	3.2
PO4	0.00	≤0.04	0.04	≤0.04
MPN	240.0	350.0	240.0	240.0
pH	8.0	7.8	8.2	8.1
TEMP. °F	84.0	86.0	82.0	82.0

STATION 26: 79st. CAUSEWAY E.

	1971		1972	
	June	July	June	July
D.O.	5.6	5.2	5.2	4.4
B.O.D.	1.4	4.0	4.0	3.2
PO4	0.00	0.00	0.12	0.00
MPN	540.0	240.0	79.0	350.0
pH	8.0	8.0	8.1	8.6
TEMP. °F	85.0	87.0	82.0	82.0

STATION 27: 79st. CAUSEWAY MID.

	1971		1972	
	June	July	June	July
D.O.	3.2	5.2	6.4	5.6
B.O.D.	0.3	3.2	2.4	1.6
PO4	≤0.04	0.12	0.04	0.12
MPN	920.0	7.8	350.0	1600.0
pH	7.8	7.9	8.2	7.9
TEMP. °F	85.0	88.0	82.0	83.0

STATION 28: 79st. CAUSEWAY W.

	1971		1972	
	June	July	June	July
D.O.	4.0	4.4	6.8	4.8
B.O.D.	0.7	3.2	1.6	3.2
PO4	0.00	≤0.04	0.04	0.32
MPN	170.00	1600.0	240.0	79.0
pH	7.9	7.6	8.2	8.0
TEMP. °F	86.0	84.0	82.0	82.0

Source: Dade County Pollution Control Office

TABLE 2 (Continued)

STATION 29: SHORES CONDOMINIUM

	1971		1972	
	June	July	June	July
D.O.	7.2	3.6	6.4	4.0
B.O.D.	1.0	6.4	1.6	2.4
PO4	0.00	0.24	0.04	0.12
MPN	7.8	240.0	240.0	1600.0
pH	8.1	7.6	8.1	7.9
TEMP. °F	86.0	86.0	82.0	82.0

STATION 30: FAIRMONT HOUSE

	1971		1972	
	June	July	June	July
D.O.	6.8	5.2	6.8	5.6
B.O.D.	1.4	5.6	2.4	3.2
PO4	0.00	<0.04	---	<0.04
pH	8.1	7.8	8.0	7.8
MPN	27.0	4.5	79.0	240.0
TEMP. °F	85.0	86.0	81.0	83.0

STATION 31: INTERAMA

	1971		1972	
	June	July	June	July
D.O.	6.4	7.2	7.2	3.6
B.O.D.	1.7	4.0	3.2	3.2
PO4	0.00	0.00	0.56	0.12
MPN	11.0	23.0	240.0	49.0
pH	8.0	8.0	8.1	8.0
TEMP. °F	84.0	87.0	82.0	8.3

STATION 32: BROAD CAUSEWAY W.

	1971		1972	
	June	July	June	July
D.O.	6.0	6.4	6.4	6.0
B.O.D.	1.0	4.0	1.6	1.6
PO4	0.32	<0.04	0.12	0.12
MPN	170.0	49.0	79.0	240.0
pH	8.0	8.0	8.1	8.0
TEMP. °F	84.0	86.0	82.0	8.3

Source: Dade County Pollution Control Office

TABLE 2 (Continued)

STATION 33: BROAD CAUSEWAY MD.

	1971 June	1971 July	1972 June	1972 July
D.O.	5.6	5.6	3.6	4.0
B.O.D.	1.0	4.0	3.2	2.4
PO4	0.00	0.00	0.24	0.24
MPN	23.0	2.0	1600.0	79.0
pH	8.0	8.0	7.8	7.8
TEMP. °F	84.0	88.0	82.0	83.0

STATION 34: BROAD CAUSEWAY E.

	1971 June	1971 July	1972 June	1972 July
D.O	5.6	6.0	6.8	6.4
B.O.D.	0.7	3.2	3.2	4.0
PO4	0.12	0.00	0.40	0.12
MPN	79.0	7.8	79.0	350.0
pH	8.0	8.0	8.1	8.1
TEMP. °F	84.0	88.0	82.0	83.0

STATION 35: HAULOVER MARINA

	1971 June	1971 July	1972 June	1972 July
D.O.	6.0	5.6	7.2	5.2
B.O.D.	2.1	4.0	4.8	3.2
PO4	0.00	0.00	0.32	0.40
MPN	11.0	4.5	130.0	240.0
pH	8.0	7.9	8.1	7.9
TEMP. °F	84.0	88.0	83.0	84.0

STATION 36: DADE CO. LINE

	1971 June	1971 July	1972 June	1972 July
D.O.	9.6	6.8	9.6	7.2
B.O.D.	1.0	8.0	5.6	6.4
PO4	0.00	0.04	0.56	0.24
MPN	540.0	11.0	540.0	240.0
pH	8.2	7.9	8.3	8.0
TEMP. °F	84.0	89.0	82.0	83.0

Source: Dade County Pollution Control Office

TABLE 2 (Continued)

STATION 37: SHERATON BEACH

	1971		1972	
	June	July	June	July
D.O.	10.0	7.2	10.8	7.2
B.O.D.	2.5	7.2	5.6	4.0
PO4	0.32	0.24	0.24	0.44
MPN	140.0	79.0	1600.00	240.0
pH	8.2	8.0	8.3	8.1
TEMP. °F	85.0	89.0	82.0	83.0

STATION 38: SUNNY ISLES BLVD E.

	1971		1972	
	June	July	June	July
D.O.	5.2	6.0	9.6	6.4
B.O.D.	1.7	6.4	2.4	4.0
PO4	0.12	0.32	0.32	0.12
MPN	70.0	170.0	350.0	240.0
pH	7.9	7.9	8.3	8.1
TEMP. °F	84.0	90.0	83.0	83.0

STATION 39: SUNNY ISLES BLVD.

	1971		1972	
	June	July	June	July
D.O.	3.2	4.0	3.2	3.6
B.O.D.	1.7	5.6	1.6	7.2
PO4	0.32	0.32	0.40	0.40
MPN	1600.00	79.0	350.0	540.0
pH	7.7	7.6	7.5	8.3
TEMP. °F	82.0	90.0	93.0	92.0

STATION 40: MARKER 31

	1971		1972	
	June	July	June	July
D.O.	7.2	5.6	7.2	5.2
B.O.D.	11.2	4.0	4.0	3.2
PO4	0.04	0.12	0.32	2.80
MPN	49.0	27.0	350.0	350.0
pH	8.0	8.1	8.3	8.0
TEMP. °F	83.0	86.0	83.0	83.0

Source: Dade County Pollution Control Office

TABLE 2 (Continued)

STATION 41: MARKER 43

	1971		1972	
	June	July	June	July
D.O.	7.2	5.6	8.0	4.8
B.O.D.	9.6	1.6	2.4	4.8
PO4	0.32	<0.04	0.04	1.24
MPN	---	2.0	350.00	1600.00
pH	8.0	7.9	8.0	7.9
TEMP. °F	83.0	86.0	83.0	83.0

STATION 42: MARKER 26

	1971		1972	
	June	July	June	July
D.O.	7.6	6.0	4.4	6.4
B.O.D.	9.6	2.4	2.4	4.8
PO4	0.24	<0.04	0.04	1.24
MPN	240.0	2.0	350.0	1600.0
pH	8.5	8.0	8.0	7.9
TEMP. °F	84.0	84.0	83.0	83.0

STATION 43: 1,000 YDS. N. TUTTLE CAUSEWAY

	1971		1972	
	June	July	June	July
D.O.	9.6	5.6	7.2	5.6
B.O.D.	5.6	3.2	4.8	2.4
PO4	0.12	0.00	0.04	0.84
MPN	49.0	1.8	920.0	1600.0
pH	8.2	8.0	8.0	8.1
TEMP. °F	85.0	86.0	83.0	83.0

STATION 44: 1,000 YDS. S. NORTH BAY VILLAGE

	1971		1972	
	June	July	June	July
D.O.	9.6	5.6	5.2	6.8
B.O.D.	6.4	1.6	4.0	2.4
PO4	0.04	0.12	0.00	1.20
MPN	49.0	1.8	33.0	33.0
pH	8.2	7.9	7.8	8.1
TEMP. °F	85.0	86.0	83.0	83.0

Source: Dade County Pollution Control Office

TABLE 2 (Continued)

STATION 45: MARKER 18

	1971		1972	
	June	July	June	July
D.O.	10.8	6.0	6.8	5.6
B.O.D.	6.4	3.2	4.0	3.2
PO4	0.56	0.00	0.04	0.44
MPN	130.0	1.8	920.0	130.0
pH	8.9	8.0	8.1	8.1
TEMP. °F	84.0	87.0	83.0	83.0

STATION 46: MARKER 21

	1971		1972	
	June	July	June	July
D.O.	8.8	6.4	7.6	6.8
B.O.D.	11.2	3.2	3.2	1.6
PO4	0.44	0.00	0.12	0.40
MPN	23.0	1.8	540.0	350.0
pH	8.9	8.0	8.2	8.2
TEMP. °F	85.0	86.0	83.0	83.0

STATION 47: DUMFOUNDING BAY

	1971		1972	
	June	July	June	July
D.O.	9.6	6.4	10.0	9.2
B.O.D.	5.6	3.2	4.0	4.8
PO4	0.64	0.24	0.04	0.64
MPN	33.0	9.3	920.0	240.0
pH	8.3	8.0	8.5	8.4
TEMP. °F	84.0	88.0	83.0	82.0

STATION 48: MAULE LAKE

	1971		1972	
	June	July	June	July
D.O.	14.0	5.6	10.8	8.4
B.O.D.	8.8	3.2	3.2	2.4
PO4	0.92	0.32	0.04	0.24
MPN	49.0	17.0	920.0	1600.00
pH	8.5	7.8	8.0	8.4
TEMP. °F	85.0	86.0	84.0	82.0

Source: Dade County Pollution Control Office

TABLE 3

SAMPLING STATIONS ALONG COASTLINE FROM SOUTH TO NORTH

Station	Location	1971 Ave.DO	Comments
Station 1:	Gables by the Sea	6.2	
Station 2:	Gables Waterway	5.6	Drainage from waterway
Station 3:	Dinnery Key	4.9	Marina with no onshore facilities
Station 10:	Rickenbacker Causeway W.	7.5	
....			Miami River drains
Station 11:	Miamarina	6.2	Marina with no onshore facilities
Station 18:	Venetian Causeway W.	6.9	
Station 41:	Marker 43	6.8	
Station 19:	Julia Tuttle Causeway W.	6.8	
Station 40:	Marker 31	6.6	
....			Little River drains
Station 28:	79 St.Causeway W.	5.4	
Station 46:	Marker 21	6.6	
....			Biscayne Canal drains
Station 29:	Shores Condominium	5.5	
Station 32:	Broad Causeway W.	6.3	
Station 30:	Fairmont House	5.8	
Station 31:	Interama	6.3	
....			Oleta River drains
Station 39:	Sunny Isles Blvd.W.	4.7	
Station 47:	Dumfounding Bay	7.5	
Station 37:	Sheraton Beach	6.4	

Chapter 4 - COST ESTIMATES

The "Interim Water Quality Management Plan for Metropolitan Dade County" prepared by Greeley and Hansen, and Connell Associates, Inc. was used as a basis for cost estimates. Prior to the publication of the Water Quality Management Plan independent cost estimates had been developed for the purposes of this study and are presented in Appendix I.

Average annual sewage flows 1975-2000 were estimated in the management plan on the basis of total population and of industrial and commercial land use.

The estimated average annual sewage flows in million gallons per day are as follows:

	1975	1980	1990	2000
Domestic	127.2	160.8	206.8	244.8
Industrial	18.8	23.6	31.6	43.7
Commerical	22.8	25.4	29.6	32.3
Total	168.6	209.8	268.0	320.8

Costs for treating these flows were estimated for an activated sludge process and a physical-chemical process. These are secondary and tertiary processes where the tertiary process is in addition to the primary and secondary processes and uses sophisticated methods to remove greater than 90% of the BOD load from the water. (For more information on these processes see chapter eight of the Water Quality Management Plan.)

Fifteen alternate plans were developed that include the collection, transmission, and treatment of waste, the operation and maintenance of sewage treatment plants, and the disposal of effluents, via outfalls, to the ocean. The plans vary as to size and location of sewage treatment plants but all comply with Environmental Protection Agency regulations and meet requirements for federal assistance.

The projects were evaluated in the management plan with regard to the following criteria: 1) initial capital cost, 2) ultimate capital cost, 3) initial annual average cost, 4) ultimate annual average cost, 5) flexibility with other alternate plans in 1985 so that treatment plant capacity existing at that time will not be abandoned, 6) relative recycle potential measured by non-coastal treatment plant capacity in 1985 and 2000, 7) compatibility with present construction programs, 8) feasibility of initial pollution abatement program measured by its departure from the previously recommeded plan and the number of new treatment plants to be constructed. Each alternate plan was evaluated and ranked in numerical order. Alternates A, A-1, and E-3, were less costly than alternate G-1, the recommended plan, but were considered less satisfactory than G-1. Alternate A has the least potential for effluent reuse, and next to least flexibility with other plans. Alternate A-1 was found unsatisfactory for the same reasons and because it would require three new treatment plants, a new bay crossing, and several major sewage interceptors. E-1 was considered unacceptable since it ranked next to least with respect to recycle potential.

Costs estimates developed by Greeley and Hansen and Connell Asso., Inc. for each water quality plan are presented in Table 4.

Since the estimates were not discounted they do not represent the value today of future costs. The present value of the capital cost of each project was therefore found by multiplying the outlay by $1 / (1+r)^i$, where r is the discount

TABLE 4

PROJECT COST ESTIMATES

Alternate	Capital Cost -$1000 1973-1980	Capital Cost -$1000 1980-1985	Capital Cost -$1000 1985-2000	Total Capital Cost -$1000 1973-2000	Avg. Annual Cost -$1000 1980	Avg. Annual Cost -$1000 2000
A	221,543	20,127	77,146	318,816	25,312	33,219
A-1	223,761	20,128	82,306	326,195	24,543	34,089
B	250,932	17,013	64,848	332,793	28,118	35,663
C	247,245	17,030	67,337	331,612	28,057	35,662
D-1	223,697	20,128	79,577	323,402	26,065	34,523
D-2	227,870	23,523	78,586	329,979	26,514	34,928
D-3	230,086	23,523	83,746	337,355	26,844	35,808
E-1	235,351	15,214	67,228	317,793	25,832	34,395
E-3	219,440	17,030	85,475	321,945	25,147	34,838
G	231,079	15,908	79,405	326,393	25,731	34,762
G-1	228,988	12,810	77,522	319,320	25,661	34,846
H	238,419	18,589	72,487	329,495	26,813	34,510
I	255,501	11,369	70,447	337,317	27,537	35,318
J	254,832	9,416	72,247	336,495	27,349	35,209
K	239,708	17,030	72,607	329,345	26,776	34,695

1) Capital cost includes an allowance of 20% of construction cost for engineering, administration, inspection and contingencies.
2) Annual costs includes the costs of operation, maintenance and amortization of capital.
3) All costs are at a U.S.D.I. Index of 188.

Source: Greeley and Hansen, and Connell Associates, Inc., Interim Water Quality Management Plan, p. 9-56.

rate and i the year in which the funds were expended. If funds are expended over a series of years, and are approximately the same from year to year, as are operating costs, present value is found by multiplying yearly costs by $1/\sum_{i=1}^{n} (1+r)^i$ where n is the last year of the time period under consideration, see Appendix III for discussion.

Before finding present values, operating costs were separated from total costs, and additional capital costs were added to the capital costs of Table 4. Amortization of capital, included in annual costs, remained as part of operating costs.

To separate capital or construction costs from operating costs, the total capital cost of each project was divided by 28 to find the average annual operating cost. See table 5. This was then subtracted from the average annual costs for 1980 and 2000 as presented in Table 4, leaving average annual operating costs. In the report, the year 1980 was considered representative of the period of operation from 1975-1984, and the year 2000 for the period 1985-2000.

In Table 6, the capital costs from Table 4 were adjusted to include other costs to society of pollution abatement not included in the report. The Dade County Port Authority has funded 2.3 million for a waste collection system to be constructed at the Miami Internation Airport in the immediate future.[13] This figure was included into capital costs of the first period, 1973-1979.

Part of the cost of municipal sewage treatment and another cost not included in the Water Quality Management Plan is the cost of incorporating the

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[13] Communication of the Dade County Port Authority.

TABLE 5

AVERAGE ANNUAL OPERATING COSTS

Alternate	Total Capital Cost -$1000 1973-2000 (from Table 4)	Ave. Annual Capital Cost -$1000 1973-2000 (Total Capital Cost / 28)	Ave. Annual Operating Cost -$1000 1975-1984 (Ave. Capital Cost minus Ave. Annual Cost from Table 4)	Ave. Annual Operating Cost 1985-2000
A	318,816	11,386	13,926	21,833
A-1	326,195	11,650	12,893	22,439
B	332,793	11,885	16,233	23,778
C	331,612	11,843	16,214	23,819
D-1	323,402	11,550	14,515	22,973
D-2	329,979	11,785	14,729	23,143
D-3	337,355	12,048	14,796	23,760
E-1	317,793	11,350	14,482	23,045
E-3	321,945	11,498	13,649	23,340
G	326,393	11,657	14,074	23,105
G-1	319,320	11,404	14,252	23,442
H	329,495	11,768	15,045	22,742
I	337,317	12,047	15,490	23,271
J	336,495	12,018	15,331	23,191
K	329,345	11,762	15,014	22,933

TABLE 6

TOTAL CAPITAL COSTS

Alternate	Capital Costs -$1000 1973-1979 (from Table 4)	Capital Cost of Waste Collection System-Int'l Airport-$1000	Total Capital Costs -$1000 1973-1979
A	221,543	2,300	223,843
A-1	223,761	2,300	226,061
B	250,932	2,300	253,232
C	247,245	2,300	249,545
D-1	223,697	2,300	225,997
D-2	227,870	2,300	230,170
D-3	230,086	2,300	232,386
E-1	235,351	2,300	237,651
E-2	219,440	2,300	221,740
G	231,079	2,300	233,379
G-1	228,988	2,300	231,288
H	238,419	2,300	240,719
I	255,501	2,300	257,801
J	254,132	2,300	257,132
K	239,708	2,300	242,008

TABLE 6

(CONTINUED)

Alternate	Capital Costs -$1000 1980-1984 (from Table 4)	Capital Costs of gravity lines, pumping stations, and hook-ups for unsewered areas and Costs of industrial pre-treatment -$1000	Total Capital Costs -$1000 1980-1984
A	20,127	431,996	452,123
A-1	20,128	431,996	452,124
B	17,013	431,996	449,009
C	17,030	431,996	449,026
D-1	20,128	431,996	452,124
D-2	23,523	431,996	455,519
D-3	23,523	431,996	455,519
E-1	15,214	431,996	447,210
E-3	17,030	431,996	449,026
G	15,908	431,996	447,904
G-1	12,810	431,996	444,806
H	18,589	431,996	450,585
I	11,369	431,996	443,365
J	9,416	431,996	441,412
K	17,030	431,996	449,026

TABLE 6

(CONTINUED)

Alternate	Capital Costs -$1000 1985-2000 (from Table 4)	Capital Cost of future needs in gravity lines, pumping stations, and hook-ups -$1000	Total Capital Costs-$1000 1985-2000
A	77,146	460,437	537,583
A-1	82,306	460,437	542,743
B	64,848	460,437	525,285
C	67,337	460,437	527,774
D-1	79,577	460,437	540,014
D-2	78,586	460,437	539,023
D-3	83,746	460,437	544,183
E-1	67,228	460,437	527,665
E-3	85,475	460,437	545,912
G	79,405	460,437	539,842
G-1	77,522	460,437	537,959
H	72,487	460,437	532,924
I	70,447	460,437	530,884
J	72,247	460,437	532,684
K	72,607	460,437	533,044

TABLE 7

DISCOUNTED VALUES OF TOTAL CAPITAL COSTS AND AVERAGE OPERATING COSTS, 1973-2000

Alternate	Total Capital Costs -$1000 1973-79 undiscounted*	Present Value Capital Costs -$1000 1980-1984 (Total Capital Costs discounted by $1/(1+r)^7$, r=6%, r=12%)	Present Value Capital Costs -$1000 1985-2000 (Total Capital Costs discounted by $1/(1+r)^{12}$, r=6%, r=12%)
A	223,843	300,707	267,179
	223,843	204,495	137,998
A-1	226,061	300,708	269,743
	226,061	204,496	139,322
B	253,232	298,636	261,067
	253,232	203,087	134,841
C	249,545	298,647	262,304
	249,545	203,094	135,480
D-1	225,997	300,708	268,387
	225,997	204,496	138,622
D-2	230,170	302,966	267,894
	230,170	206,031	138,367
D-3	232,386	302,966	270,459
	232,386	206,031	139,692
E-1	237,651	297,439	262,249
	237,651	202,273	135,452
E-3	221,740	298,647	271,318
	221,740	203,094	140,136
G	233,379	297,901	268,301
	233,379	202,587	138,577
G-1	231,288	295,840	267,366
	231,288	201,186	138,094
H	240,719	299,684	264,863
	240,719	203,800	136,802
I	257,801	294,882	263,849
	257,801	200,534	136,278
J	257,132	293,583	264,744
	257,132	199,651	136,740
K	242,008	298,647	264,923
	242,008	203,094	136,832

TABLE 7
(CONTINUED)

Alternate	Present Value Operating Cost -\$1000 (Average Annual Operating Cost discounted by $\sum_{1}^{12} 1/(1+r)^i$; r=6%,12%)	Present Value Operating Cost -\$1000 (Average Annual Operating Cost discounted by $\sum_{13}^{28} 1/(1+r)^i$; r=6%,12%)	Total Capital and Operating Costs* -\$1000 discounted at 6%, 12%	Evaluation
A	91,224	109,652	992,605	- at 6%, lowest
	62,727	39,081	668,144	estimate
A-1	84,457	112,695	993,664	- at 12%, the
	58,074	40,166	668,119	lowest
B	106,336	119,420	1,038,691	- at 6% and 12%
	73,118	42,563	706,841	highest estimate
C	106,211	119,626	1,036,333	
	73,033	42,636	703,788	
D-1	95,082	115,377	1,005,551	
	65,380	41,122	675,617	
D-2	96,484	116,231	1,013,745	
	66,344	41,426	682,338	
D-3	96,923	119,330	1,022,064	
	66,646	42,530	687,285	
E-1	94,866	115,739	1,007,944	
	65,231	41,251	681,858	
E-3	89,410	117,220	998,335	
	61,479	41,779	668,228	
G	92,193	116,040	1,007,814	
	63,394	41,358	679,295	
G-1	93,359	117,733	1,005,586	- the chosen
	64,195	41,961	676,724	plan
H	98,554	114,217	1,018,037	
	67,767	40,708	689,796	
I	101,469	116,874	1,034,875	
	69,772	41,665	706,050	
J	100,427	116,472	1,032,358	
	69,055	41,512	704,090	
K	98,351	115,176	1,019,105	
	67,628	41,050	690,612	

*Note: Wherever costs were expended over a series of years, it was assumed the total capital cost was expended in the first year.

unsewered population into sewerage districts. The cost of providing gravity lines to individual households from existing transmission lines will be approximately \$18/ft.[14] The additional cost to the household for hook-up to these street mains will be \$100-\$1,200/unit.[15] With 172,886 occupied units in Dade County without public sewer service,[16] this represents a cost range of \$17,288,600 to \$207,463,200 for hook-ups, and \$331,433,088 for gravity lines. These costs are included in Table 6 in the 1980-1984 period, with the cost of hook-ups represented by a \$100 million figure.

The cost of providing gravity lines was estimated with the aid of Figure 3, where the number of square miles left unsewered could be roughly approximated by placing a grid over the figure. Required are 119 square miles of 15,079,680 running feet[17] and 238 (2 per square mile) pump stations at \$20,000 per station.

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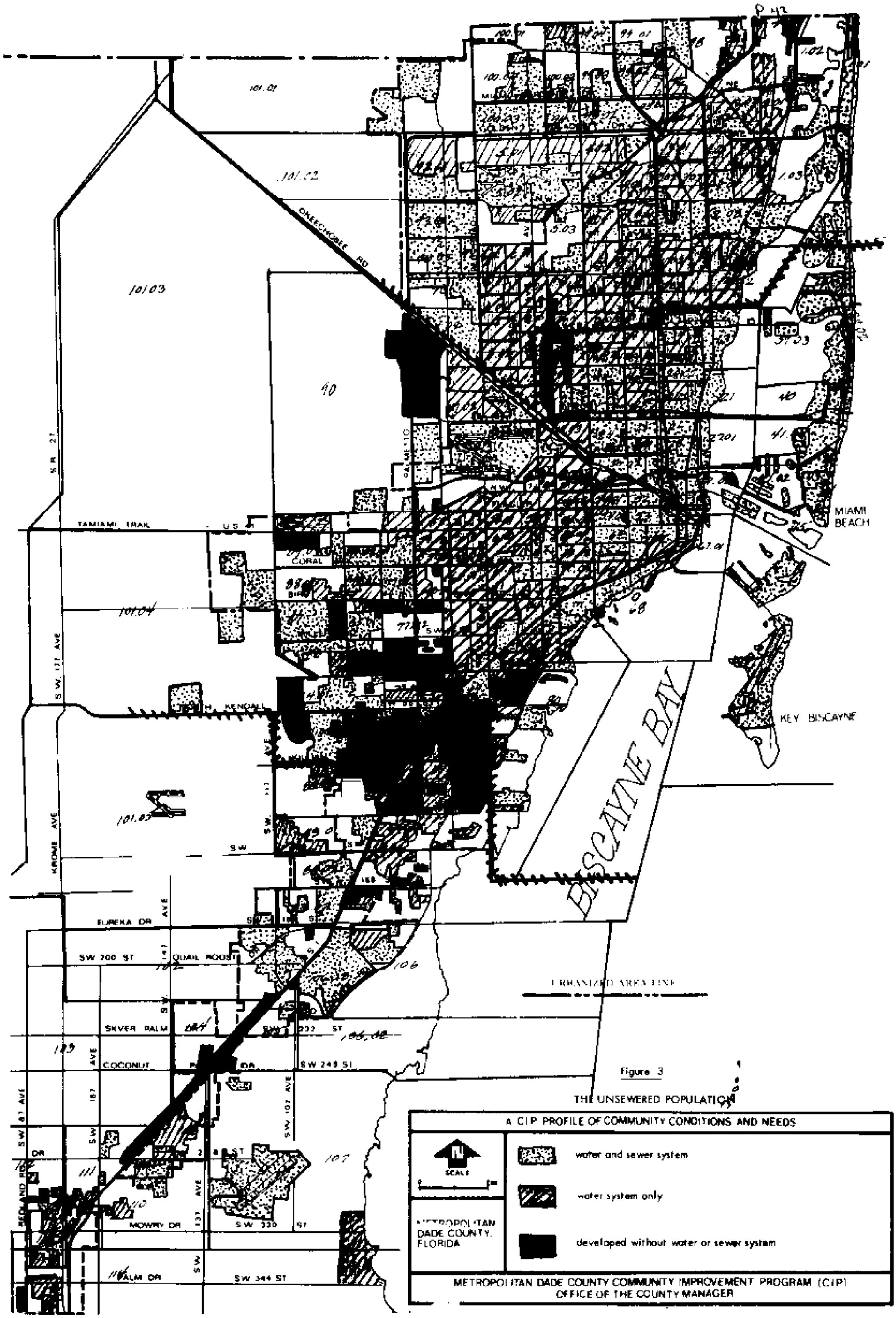
[14] The cost per gravity foot of both gravity lines and force mains is approximately one dollar per inch diameter per running foot of pipe laid in place. Many of the larger transmissionlines are already in place. Data provided courtesy of the Hialeah Department of Water and Sewers, and includes force mains, gravity lines, and contingencies.

[15] Data provided courtesy of the Dade County Department of Public Works.

[16] Data provided courtesy of the Dade County Community Improvement Program.

[17] There are 10 blocks in a mile traveling East-West and 16 blocks in a mile traveling North-South. To interlace a square mile of a populated area with sewer mains will require 26 minus 2(to avoid double counting on adjacent grids), or 126,720 feet. Figuring it at \$18/ft., and 119 square miles, or \$27,434,240 and including 238 pump stations at \$20,000 each, and 20% allowance for easements, engineering inspection, interest, and administration, gives a total of \$331,433,088.


MIAMI BEACH
KEY BISCAYNE
BISCAYNE BAY
TAMIAMI TRAIL
KROME AVE
EUREKA DR
QUAIL ROOST
SW 200 ST
CORAL
MOWRY DR
PALM DR
COCONUT
URBANIZED AREA LINE
Figure 3
THE UNSEWERED POPULATION
A CIP PROFILE OF COMMUNITY CONDITIONS AND NEEDS
SCALE
water and sewer system
water system only
developed without water or sewer system
METROPOLITAN DADE COUNTY, FLORIDA
METROPOLITAN DADE COUNTY COMMUNITY IMPROVEMENT PROGRAM (CIP)
OFFICE OF THE COUNTY MANAGER

Assuming \$100,000,000 will be the cost of hook-ups to street mains, this is a total cost of \$431,433,088 to sewer present unsewered areas. The area to be covered is 119 square miles, so this is an average cost of \$3.625 million per square mile. This figure will be used to estimate the cost of gravity lines, pumping stations, and hook-ups for growth areas.

Another cost unaccounted for in the Water Quality Management Plan and included in Table 6 as a capital cost for the 1980-1984 period, is the cost that must be carried by industry to pre-treat its effluents before connection to the city sewerage system.

The Industrial Waste Survey[18] identified the largest dischargers[19] to surface waters as follows:

Canada Dry Bottling Company provides settling for its wastes, with not automatic sludge removal and it discharges to the 58th Street Canal;

Farm Stores utilizes an activated sludge treatment process, chlorinating satisfactorily, and achieving 98% removal efficiencies of BOD, COD, and TSS;

Florida Processing Company treats its effluents by skimming and aerating and achieves high removal efficiencies, trucking its refuse to the Virginia Key plant;

Miami Board, a Division of Simkins Industries, Inc. discharges 1167 lbs/day BOD and 388 lbs/day TSS tothe Tamiami Canal, and after being brought to court has agreed to connect to a sewer system;

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[18] Lower Florida Estuary Study, Industrial Waste Survey, Dade County, Florida (Athens, Ga.: Environmental Protection Agency, 1971), pp. 9-14

[19] Discharging 92% of the total industrial BOD load surveyed.

Pepsi Cola Bottling Co. provides settling without sludge removal or chlorination and discharges 5,00 per 100 ml. of fecal coliform to the Dressels Dairy Canal.

Results of inquiries into these industries show a total of $310,000 will be spent on eliminating polluting substances from their wastes. Although Farm Stores continues to discharge to the 58th Street Canal, its liquid effluent is clean and an additional $50,000 will be invested to connect to the Dade County Sewer System sometime in 1972-1973.

Devices for pretreatment of wastes at Pepsi Cola Bottling Co. will run $18,000.

Florida Processing Company has recently invested considerable sums and will soon invest another $110,000 in treating its effluent.

Miami Board, and Canada Dry did not respond to inquiries. However, Canada Dry utilizes one-fourth the amount of water Pepsi Cola does so an estimate was possible.

Miami Board, utilizing large amounts of water in the production of cardboard will be the largest investor of the group, estimated at $200,000.

TABLE 8

COST OF PRETREATMENT OF INDUSTRIAL EFFLUENTS

Farm Stores	$ 50,000
Pepsi Cola	162,000
Florida Processing	110,000
Canada Dry	40,500
Miami Board	200,000
Total	$ 562,500

The total amount included as capital costs in the 1980-1984 period is $431.996 million as follows: $331.433 million in gravity lines, $100 million in hook-ups, and $.563 in industrial pre-treatment costs.

During the 1985-2000 period additional gravity lines and household hook-ups will need to be installed to sewer growth areas of the city. A process similar to that of estimating, in square miles, the present unsewered areas of the county, was performed on a map of the Land Use Master Plan of the Dade County Planning Department.

A grid was placed over present undeveloped, unsewered areas, that according to the Master Plan will be populated in 1985. It was estimated that 127 square miles will need to be sewered by 1985. At the average cost of $3.625 million per square mile, found to be the cost of sewering unsewered areas, this is a total cost of $460.437 million to provide gravity lines, pumping stations, and hook-ups in growth areas. This cost was included in capital costs for the 1985-2000 period in Table 6.

Table 7 presents the discounted values of these total capital and operating cost estimates. It must be stressed that these are only rough estimates and one should keep in mind the assumptions made in constructing them.

The cost range for all alternate plans is $992.605 million to $1,038.691 million discounted at 6%, and $668.119 million to $706.841 million discounted at 12%.

Chapter 5 - BENEFITS OF POLLUTION ABATEMENT

Some of the benefits that could accrue to Dade County from the abatement of pollution of its canals and of Biscayne Bay are: increased marine animal production, decreased health hazards, and increased use of the Bay for recreational activities, including the visual aesthetics of cleaner waters.

In examining catch and effort data from the National Marine Fisheries Service of the Department of Commerce to determine the effect of polluted waters on fishery catch in Biscayne Bay, no conclusion could be drawn by simple examination of the data. A study of the effects of pollution on fish production would require analysis and measurement of changes in fish populations, changes made in gear used in catching the fish (as it affects effort), movements (if any) of fish populations and their source of food, etc., and is beyond the scope of this study.

Upon consultation with Public Health officials on the present health hazard posed by polluted waters in Dade County, no danger was seen by them at this time. Likewise, the effect on health of cleaner waters cannot be estimated.

Therefore, the benefits accruing to Dade County for the purposes of this study are the benefits of increased recreational activities. It is recognized that this will only be a partial measure of the total benefits that could accrue to the County, however hypothetical values shall be placed on these other benefits once the benefits to recreation have been determined.

Measuring and valuing recreational benefits is not an easy task. Various methods have been used to measure the stream of benefits of a water-based recreation resource. Some are correct, others unsatisfactory. Valuing a beach or a sports fishery at the cost of providing and maintaining facilities is circular in reasoning. What it costs is not necessarily what it is worth. Equating it at gross expenditures by its users only tells us how much would be spent somewhere else if the resource were no longer available, not specifically how much it is worth to its users. Likewise, valuing a sports fishery at the value of the fish caught is valuing fish not fishing.

The value of a recreation resource is the value it has to the consumer, measured by the consumer's "willingness to pay." Whether or not he is actually charged for using the resource is not important.

Hotelling,[20] Brown et al.,[21] and Clawson[22] have shown that income, travel time, and transfer costs (other costs not included in prices) are the relevant determinants of demand for outdoor recreation. Degree of attractiveness of the site, and relative overcrowding can also be included, as well as the quality of the water for swimming, and fishing success per unit of effort for fishing. A study involving these variables in the demand for outdoor recreation was not possible due to its high cost in man hours and in the time involved. This study was built on

[20] Harold Hotelling, Letter, quoted in National Park Service, The Economics of Public Recreation: An Economic Study of the Monetary Evaluation of Recreation in the National Parks, (Washington, D.C.: U.S. Dept. of Interior, 1949).

[21] William Brown, Ajmer Singh, and Emery Castle, "An economic evaluation of the Oregon salmon and steelheal sport fishery" Oregon Agricultural Statistical Bulletin No. 78, 1964.

[22] Marion Clawson, "Methods of measuring the demand for and value of outdoor recreation" RFF Reprint Number 10, (Washington D.C.: Resources for the Future, 1959).

data already available.

Information on tastes was taken from a study of the recreational demands of the residents of Dade County conducted by the Park and Recreation Department. It patterns recreational activities preferred as "definitely water oriented."[23] Swimming and fishing are the most frequently pursued activities, followed by water-based picnicking and boating. Of the respondents of the survey, 57.7% identified one or more water-oriented leisure time activities as those most popular in their family, and 78% mentioned enjoying some sort of water-based recreation activity.

Overcrowding kept 25% of the survey respondents away from recreational activities, while travel time discouraged another 18% and insufficient leisure restricted 20%.[24]

While we cannot estimate directly what people are willing to pay for increased or improved recreational facilities, it is possible to get a rough measure of the maximum recreational services that Biscayne Bay can provide. By assigning various values to this capacity, it is possible to get an estimate of the maximum increase in value that pollution abatement can provide. This can only be a ceiling value and in no way implies full use will be made of the maximum capacity.

Attendance at Haulover Park where swimming is a major activity,

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[23] Dade County Park and Recreation Department and Dade County Planning Department, Public Recreation Patterns and Demand in Metropolitan Dade County (Central Service Courthouse, 1968), p. 4.

[24] Ibid, p. 49.

October 1970 – September 1971 was 41,961.6 persons/acre, while that at Matheson Hammock (where only 1,007 persons swam during the same time period due to low water quality) was 5,542.3 persons/acre. Attendance at Crandon Park was 8,266.7 persons/acre. It is assumed attendance at Matheson Hammock and elsewhere (especially at Virginia Beach, having facilities equal to those at Haulover) would be greater if these sites enjoyed the quality of water existing at Haulover Beach, but it is acknowledged that poor water quality is not the only reason attendance is discouraged.

Tables 9 and 10 compare the capacity of Biscayne Bay for recreational activity with usage under present conditions. Capacity is estimated by considering such factors as physical size, and space required for the activity; for swimming it is estimated at 10,000 persons/acre. This figure is somewhat larger than attendance at Crandon Park, but it is not as large as attendance at Haulover. Capacity was first estimated at 41,961.6 persons/acre (attendance at Haulover), but this would have meant capacity at Crandon Park would be 30 million more than attendance last year. This was considered unacceptable upon realization of the crowded conditions existing at the park on week-ends. The 10,000 figure was settled upon to permit increased attendance at Crandon Park but by only one million and a half. Excess or unused capacity due to unclean water was then estimated at one-third total excess capacity, the difference between capacity and usage under present conditions.

Capacity in boating activities was estimated by the number of launchings physically possible from every available ramp in a 12 hour period of daylight. It is assumed one small boat can be placed in the water and then

TABLE 9
COMPARISON OF CAPACITY AND PRESENT USAGE OF THE BISCAYNE BAY AREA AS A RECREATION RESOURCE, PICNICKING AND SWIMMING

	Capacity (activity day/yr)*	Usage (activity day/yr)	Excess capacity (capacity minus usage divided by 3)
Crandon Park (903 acres)	9,030,000 (a)	7,464,826 (b)	521,724
Matheson Hammock (629 acres)	6,290,000 (a)	3,486,109 (b)	934,630
Virginia Beach (145 acres)	1,450,000 (a)	496,379 (b)	317,874
Haulover (144 acres)	6,042,479 (over capacity exists)	6,042,479 (b)	-
TOTAL	22,812,479	17,489,713	1,774,228

*Defined as one visit to the site by one person during a 24 hour period.

(a) Area times 10,000 (defined as capacity).

(b) Source: Dade County Park and Recreation Department.

TABLE 10

COMPARISON OF CAPACITY AND PRESENT USAGE OF BISCAYNE BAY AS A RECREATION RESOURCE, BOATING

	Capacity (activity day/yr)*	Usage (activity day/yr)	Excess Capacity/3**
Matheson Hammock (launching ramp for 17 boats)	148,920 (a)	26,298 (b)	40,874
Haulover (launching ramp for 26 boats)	227,760 (a)	123,481 (b)	34,760
Homestead Bayfront (launching ramp for 6 boats)	52,560 (a)	23,262 (b)	distance may be discouraging attendance
Dinner Key (launching ramp for 6 boats)	52,560 (a)		5,840
Virginia Key: Crandon Marina (launching ramp for 28 boats)	245,280 (a)		81,760 (c)
Rickenbacker Causeway (launching area for 142 boats)	1,243,930 (a)		414,640 (c)
West point of Key (launching area for 95 boats)	832,200 (a)		277,400 (c)
Total	2,803,200		855,274

*Defined as one boat launching every one-half hour (15 minutes for launching, 15 minutes for dockage) during twelve hours of daylight.

**One third capacity minus usage.

(a) Launching space times 24 times 365.

(b) Source: Dade County Park and Recreation Department.

(c) Assuming 1/3 capacity.

returned to its trailer in one-half hour. Launching capacity at the parks was then checked with the available parking spaces to assure no restraint would be placed on capacity by parking area.

At the public parks launching area was determined by estimating how many trailers could be loading or unloading at one time. The number of these trailers (allowing each about 10 feet) multiplied by 24 one-half hour periods in twelve hours of daylight, multiplied by 365 days in the year, yields capacity. Excess capacity due to unclean water was estimated at one-third total excess capacity.

Boat launching capacity at Virginia Key was estimated after visiting the area. Besides the Crandon Park Marina ramp, wooded beach areas along both sides of Rickenbacker Causeway and a portion of Virginia Key itself, are used to launch small boats. Due to the number of trees, only one-third of the area, 500 yards and 333 yards respectively, was used in determining the number of trailers that could be loading or unloading during daylight hours (estimated at 3 and 1/2 yards per boat).

The effect of decreased water quality on recreation can be summarized as follows:

1) Existing investment in public and private beaches cannot be fully utilized (Virginia Key, Matheson Hammock), i.e. excess capacity exists.

2) Revenues from greater use of the area by the general public are lost, although this figure is not being estimated in this study.

3) Further development of recreation sites on bay front property is discouraged since swimming and boating could not be enjoyed.

This last point justifies defining capacity as attendance at one park and comparing it to attendance at other parks, even though the amount of developed acreage may differ from park to park. It is assumed that if the demand for beaches was great enough, demand would be fulfilled wherever water quality permitted.

Tables 9 and 10 can be used to estimate the recreational value of Biscayne Bay lost to the public by decreased water quality (among other things). Recreational value is found by multiplying excess or unused capacity by dollar participation values for both picnicking and swimming and boating activities, and discounting. The dollar values placed on unused capacity are presented in figures 4 and 5.

The top line in figure 4 shows that if excess capacity in swimming is valued at $1/person and discounted at 6%, excess capacity in boating must be valued at $88.71/boat to cover the bottom range of the cost estimate discounted at 6%, and at $92.92/boat to cover the top range of the cost estimate. If swimming is valued at $5/person, boating must be valued at $95/boat to cover the top range of the cost estimate, and at $89.228 to cover the bottom range. If swimming is valued at $10, boating must be valued at $84.628/boat to cover the top range of the estimate, and at $78.885 to cover the top range, etc. Values discounted at 12% are found and presented similarly in figure 5.

At Matheson Hammock and Virginia Beach at least, low water quality is discouraging swimming. Boating activities, including fishing, water skiing, and skin diving, elsewhere on the Bay, are similarly discouraged.

FIGURE 4

COMBINATION OF VALUES FOR BOATING AND PICNICKING AND SWIMMING EXPERIENCES WHERE PRESENT VALUE OF TOTAL BENEFITS = PRESENT VALUE OF TOTAL COSTS

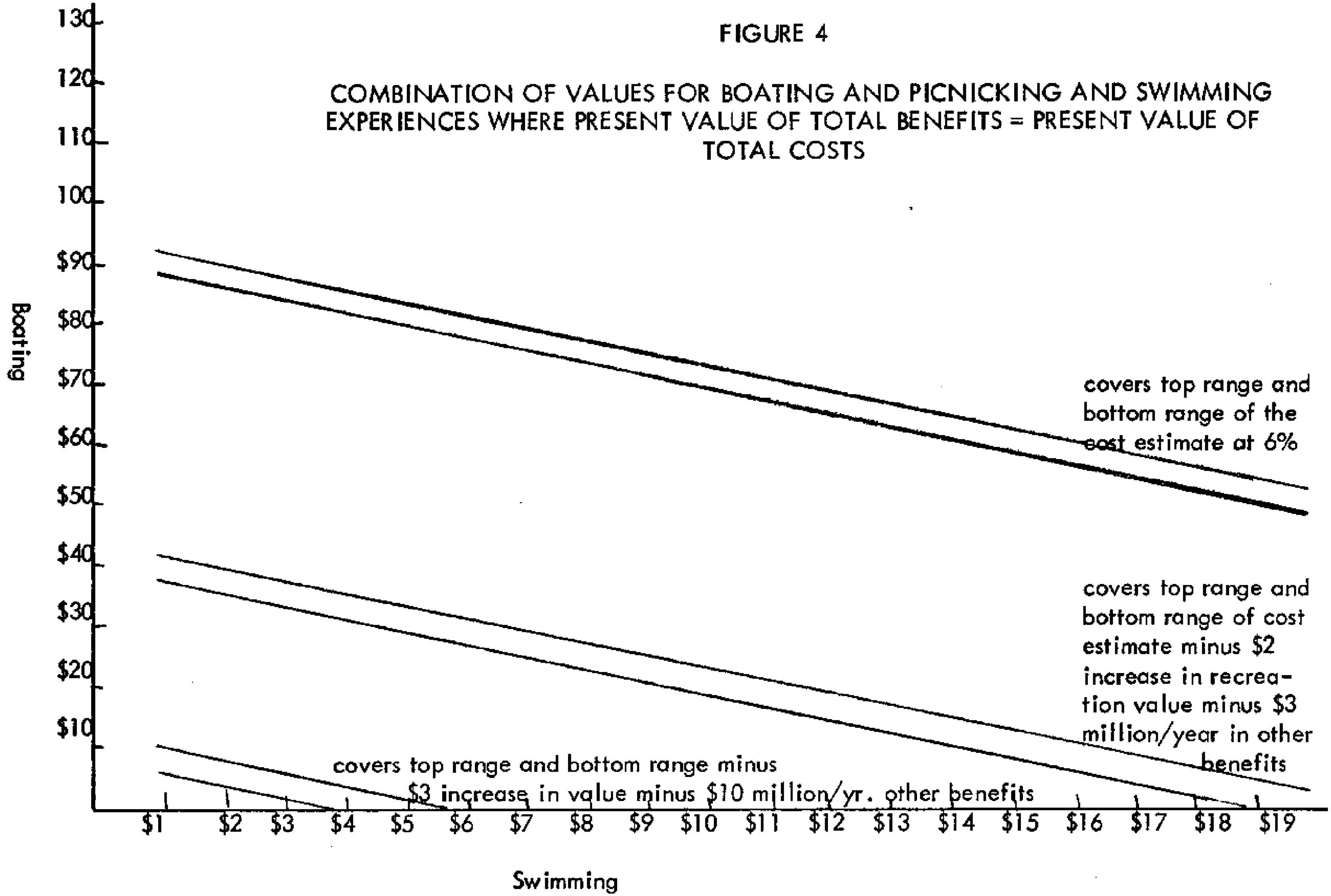
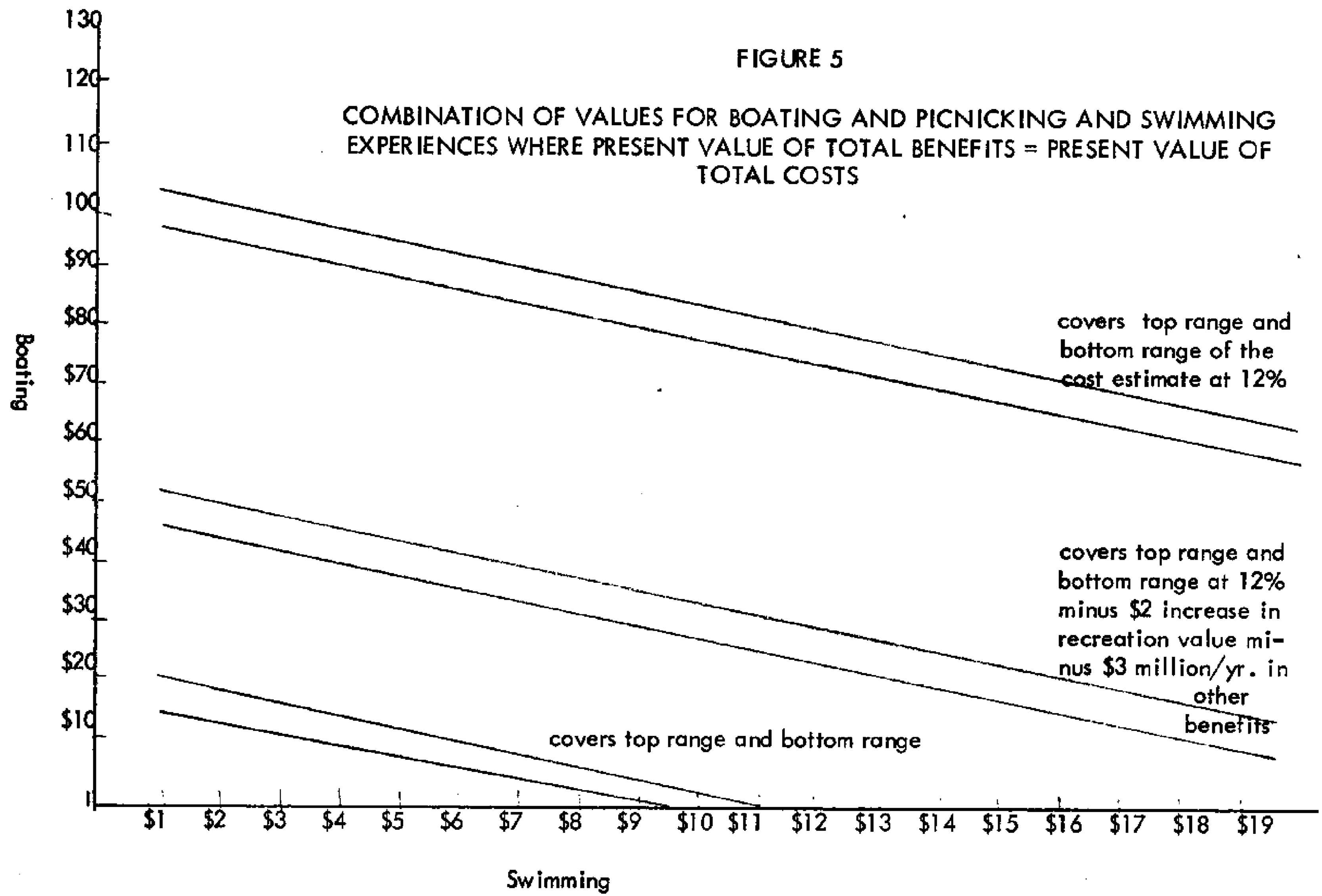


FIGURE 5

COMBINATION OF VALUES FOR BOATING AND PICNICKING AND SWIMMING EXPERIENCES WHERE PRESENT VALUE OF TOTAL BENEFITS = PRESENT VALUE OF TOTAL COSTS



However, use is being made of the bay at existing water quality, at a certain value to its users. With cleaner waters the value of recreational experiences on the bay to these users will increase. This increase in value is estimated by multiplying 20,200,000 by $2/person/day in one estimate and by $3/person/day in another estimate, and discounting. (Twenty million is estimated as the present number of swimmers per year and two hundred thousand the present number of boats on the bay per year, see tables 9 and 10; $2 and $3 are hypothetical estimates.)

When these estimates, as well as two different estimates of additional benefits stemming from pollution abatement not measured in this study, are subtracted from the total cost estimates, values that need be placed on unused capacity fall considerably, see bottom and middle lines of figure 4 and 5. Additional benefits, those of increased fish production and decreased health hazards, are hypothetically estimated at $3 million per year (the value of the total fish catch out of Biscayne Bay last year was $3 million), and at $10 million per year.

When a $3/person/day increase in value, and $10 million per year in additional benefits is estimated, the values of a day boating on the bay and picnicking on the beach fall to less than the $3 estimated increase in value. Ten million dollars per year in benefits to health or to increased fish production could only be estimated with evidence of the decreased hazard of an epidemic or of increased production in ocean fish linked to its food chain or nursery in Biscayne Bay. Evidence of either is unlikely to be found.

Total yearly benefits to Dade County must be $81,260,000 at

6%, and $90,130,000 at 12% to justify the cost of pollution abatement. Estimating a $2 increase in value per day fro present users, $2 million per year in benefits to the fishing industry, and $1 million per year in benefits to health, a value of $3 a day for picnicking and swimming, and $38-$48 a day for skin diving, water skiing, or fishing from a small boat, justifies the cost of the pollution abatement plan.

Chapter 6 – SUMMARY AND CONCLUSIONS

The water quality management plan for Dade County includes plans for closing small wastewater treatment plants that discharge to inland waters, and constructing larger (50 to 80 mgd capacity) plants, with high BOD removal efficiencies, that will discharge, via outfalls, to the Atlantic Ocean and the Gulf Stream. Permits for septic tank installation have been suspended and plans for a city-wide waste collection system have been studied. The smaller, now obsolete, treatment plants will serve as pumping stations to the larger plants, of the flow they previously had treated, and additional transmission mains, gravity lines, and individual hook-ups, including hook-ups to industries discharging to surface waters, will be constructed.

This study has focused on the costs and benefits of this system. The cost of the construction and operation of the complete sewerage system has a present value of $992.605 million to $1,038.691 million discounted at 6%, and $668.119 million to $706.841 million discounted at 12%. These values were found by adjusting estimates prepared by Greeley & Hansen and Connell Associates, Inc. for the Water Quality Management Plan for Metropolitan Dade County, to include other costs to society of a complete sewerage system not included in the Management Plan. These "other costs" are the costs of constructing street mains and individual hook-ups, and the costs of industrial pre-treatment of effluents. These costs must be borne before connection of unsewered industries and households to the sewerage system can be accomplished.

The total cost will be borne by government, industry, and individuals. Federal and state funding is available to local government; industry, however, must treat its effluents for harmful, non-degradable substances, and individual units, including households, industries, and other establishments, must bear the cost of final hook-up.

The environment, and all residents and tourists of Dade County that enjoy the services the environment provides, will be the ultimate benefiters of the abatement of pollution of Biscayne Bay. Only recreational benefits have been measured here, and then only those easily quantified by the availability of data, benefits to the sport fishery and the fishing industry being difficult to determine at this time. Marginal benefits must outweigh, or equal, the cost of pollution abatement, a marginal cost of moving from the level of water quality existing today, to a higher level of water quality, one that will increase the services the environment provides. Therefore, benefits have been given a dollar value that will cover the cost of the water quality management plan.

The total value of benefits was found by estimating the upper limit of the total recreational capacity of Biscayne Bay and assigning hypothetical values to this capacity.

If Dade County citizens value a picnic lunch and a swim in the clean waters of the bay at $1/day, and a day fishing, skin diving, or water skiing, from a small boat at $89 to $92/day, benefits will cover the cost (at 6%) of pollution abatement.

These values seem a bit high. Society cannot be allocating its resources correctly by investing vast sums in abating the pollution of Biscayne Bay if the only benefits it will gain are those of increased recreational activity. However, the above argument implies that facilities are not used to their full capacity due to low water quality, and ignores the fact that the value of boating and swimming experiences at present usage rates will increase due to better water quality. Dollar values will be less if this as well as the value of additional benefits of pollution abatement are considered.

Specifically, dollar values fall to \$34 and \$38/boat to cover the cost estimate range at 6% when picnicking and swimming is valued at \$3/person, if an increase of \$2 per day in the recreational value of Biscayne Bay at present usage rates, and \$3 million per year in additional benefits is estimated. These values are more reasonable and more easily accepted, but are presented here for comparison purposes only.

It is concluded that total marginal benefits alone do not outweigh or equal the cost of the pollution abatement program due to the high values that must be placed on the recreational experiences to cover the cost of the abatement plan, but when increased recreational benefits accruing to present users, and other benefits accruing to the fishing industry, and possibly to health are considered, the present value of total benefits equals the present value of total costs _if_ users value recreational experiences on the bay at the values presented above. Upon the dictates of recreational users of Biscayne Bay, i.e. whether or not they value picnicking and swimming and boating on the bay at these values, depends the results of the analysis.

In summary, in order to justify the cost of the sewerage project, around eighty million dollars worth of benefits must be forthcoming over the next twenty eight years. (See page 57 above.) The recreational participation rates and the daily values in use given above generate such a sum. The values in use are hypothetical only; other combinations of values in use will satisfy the requirement also. (See Figures 4 and 5.)

Because of the way benefits were handled in this study, the only conclusion that can be made at this point is that the cost of cleaner waters, in terms of increases in the flow of services from the environment, is quite high. The values that must be placed on benefits are not high enough however to conclude that a misallocation of resources will result by the construction of the sewerage system.

It should be recognized that no account was taken of secondary benefits in this study. Secondary benefits in this case would include such things as the effect on tourist spending in Dade County of cleaner waters. This would include hotel bills, etc. as well as boat rentals and other expenditures directly related to the marine environment. They were ignored because from a national point of view, the secondary benefits of various sewerage projects in different parts of the country would normally cancel each other out and hence provide no useful information about how to spend Federal money. From south Florida's point of view, however, these benefits are important and quite large. Because Miami competes for tourist dollars with other areas, the cleanliness of its waters in relationship to the waters of other areas can be important. If these benefits are included in the above analysis, the values in use necessary for benefits to equal costs would be reduced. The lower set of lines in Figure 4 and 5 result from giving 10 million a year in other benefits, such as secondary tourist benefits. It can be seen that in this case the values necessary for swimming are less that $5 and those for boating are less than $10.

Further study seems to be in order. In appendix II, a chapter on theoretical considerations has been included by way of suggestion for widening the theoretical basis of the water quality management plan.. Study should also be made of additional benefits that could stem from pollution abatement in the area, especially the benefits to the fishing industry.

Appendix I - PREVIOUS COST ESTIMATES

Before publication of the Water Quality Management Plan, recent publications containing data on construction and operation of waste treatment plants were scant. Gibbs and Bothel[25] and Culp and Roderick[26] contained the most extensive information. Costs for three plants of defferent capacities were adjusted to an ENR cost index of 160 from these estimates (see table 4[a]). The secondary process, which provides for raw sewerage pumping, screening, grit removal, preaeration, sedimentation, and sludge drying on underdrained beds, removes 1150 lbs. BOD per million gallons of sewerage. When combined with a primary process, 85% removal efficiency is achieved: 1770 lbs. BOD are removed per million gallons. The tertiary process, a chemical coagulation process employing polyelectrolytes, plus carbon adsorption, is intended for addition to existing secondary treatment facilities, and removes 75 additional lbs. BOD per million gallons. (Primary, secondary, and tertiary processes distinguish three levels of operation, the tertiary process being a more advanced level of operation, using sophisticated methods to remove greater than 90% of the BOD load from the waters, while the primary process is concerned mainly with screening and removing large particles, plus sedimentation.)

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[25] Charles Gibbs and Ray Bothel, "Potential of Large Metropolitan Sewers for Disposal of Industrial Wastes" Journal of the Water Pollution Control Federation, XXXVII (October, 1965).

[26] Russell Culp and R.E.Roderick, "The Lake Tahoe Water Reclamation Plant," Journal of the Water Pollution Control Federation, XXXVIII (February, 1966).

Capital costs were amortized over 20 years at 5%. Operating costs provide for first-class operation and include maintenance, power (gas engines for generation of electric power and other equipment), supplies, and administration. All labor costs are based on a rate of $4/hr.

Table 4[a], where costs per pound BOD removed are derived, adequately portrays increasing economies of scale as plants with larger capacities are utilized. Capital costs plus operating costs divided by the pounds BOD removed in the process yields the cost per pound BOD removed. This cost per pound will be used to estimate the cost of treatment facilities to treat BOD loads from both municipal and industrial sources. All costs in this table are lower than costs cited by Connell Associates in the Water Quality Management Plan.

Table 5[a] shows the cost of removal. Column 1 provides the existing effluent loads, in lbs. BOD per day discharged into canals or to the ocean by both major and minor treatment plants. Column 2 lists the level of efficiency achieved at each plant. Column 3 is the result of the following logic: is 309 lbs. BOD are discharged from the Andover plant, which achieves 84% removal efficiency, then 16% of the lbs. BOD that flow into the plant have <u>not</u> been removed. If 100% of the total lbs. BOD that flow into the plant have <u>not</u> been removed (zero lbs. removed) then 309/.16 flow into the plant daily.

The dollar figures in Table 6[a] represent, first, the cost of achieving 85% efficiency (with a secondary process), second, the cost of achieving 90% efficiency (a tertiary process is needed), and third, the sum of the two. For example, in the North district, to achieve 85% efficiency, 12,084.25 lbs.

TABLE 4[a]

TREATMENT COSTS PER DAY

Complete Secondary Treatment*

Capacity (mgd)	Amortized (20 yrs. at 5%) Capital $/mgd	Operating Costs $/mgd	Total $/lb. removed
1	200.42 (a)	81.80 (a)	.1594
25	80.80 (a)	30.00 (a)	.0626
50	79.58 (c)	26.93 (c)	.0602
60	79.08 (c)	25.71 (c)	.0592
80	78.11 (c)	23.25 (c)	.0572
100	77.13 (a)	20.80 (a)	.0553

Incremental Tertiary Treatment**

2.5	77.45 (b)	103.00 (b)	2.406
10	57.65 (b)	77.50 (b)	1.802
50	54.03 (c)	72.27 (c)	1.684
60	52.58 (c)	70.17 (c)	1.637
80	49.20 (c)	65.29 (c)	1.526
100	46.78 (b)	61.80 (b)	1.448

* Includes a primary treatment of 30% removal efficiency; removes 85% or 1,770 lbs. BOD per million gallons.

** Removes an additional 75 lbs. BOD.

(a) Charles Gibbs and Ray Bothel, "Potential of Large Metropolitan Sewers for Disposal of Industrial Wastes" Journal of the Water Pollution Control Federation, XXXVII (October, 1965).

(b) Russell Culp and R. E. Roderick, "The Lake Tahoe Water Reclamation Plant," Journal of the Water Pollution Control Federation, XXXVIII.

(c) By interpolation.

TABLE 5a
COST OF 90% REMOVAL EFFICIENCY - PART ONE: BOD INFLOW

Existing municipal effluent loads in lbs/day BOD*		Level of Efficiency	BOD inflow
North district			
Andover	309	84.0%	1931.25
Carol City	520	82.5%	2971.43
Riverdale Est.	190	85.6%	1319 44
Golden Isles	172	82.4%	977.27
Myrtle Grove	289	91.8%	3524.39
Country Club	6	94.5%	109.09
Palm Springs	67	92.8%	930.56
Dade Christian	5.25	69.1%	16.99
Miami Lakes	253	79.8%	1252.47
Seabord Industrial Park	31	95.0%	620.00
Opa Locka Airport	60	82.0%	0333.33
Food Fair 291	0.38	98.9%	34.54
Barry College	7.26	85.8%	51.13
Monsignor Pace High School	4.25	86.9%	32.44
Del Ray Gardens	0.62	94.4%	11.07

*Source: Environmental Protection Agency, Report of Waste Source Inventory and Evaluation, Dade County, Fla. (Athens, Ga.: EPA 1971)

Table 5 (Continued)

	Load	Level of efficiency	BOD inflow
Shores Cond.	9.84	82.3%	55.59
Palm Springs Hospital	3.39	80.9%	17.75
Palm Springs Garden	6.50	76.8%	28.02
Miami Beach	29,998.0	90.0%	will be retained in operation
TOTAL			14,216.76
Central District			
Atomic Sewerage	22.0	89.9%	217.82
Doral Country Club	53.0	90.1%	588.89
Hialeah City Hall	8.68	90.4%	144.67
Hialeah Hosp.	17.26	92.2%	215.75
Hialeah Convalescent	19.60	69.1%	63.43
Kings Inn	1.92	84.0%	12.0
Holiday Inn	0.41	98.7%	31.54
Airport Lanes	0.62	97.2%	22.14
Midway Mall	2.25	98.3%	132.35
Air Traffic Control	0.21	99.5%	4.2
Howard Johnsons	1.63	97.95	77.62
My-Am-Ee Trailer Park	5.38	96.3%	145.41

Table 5a (Continued)

	Load	Level of efficiency	BOD inflow
Florida Portland Cement	0.3	89.6%	2.88
Jade Garden Apts.		99.0%	
Miller Lake Apts.	1.15	70.9%	3.95
Lakeview Garden Apts.	6.0	89.0%	54.54
Kendale Lakes	2.5	96.9%	80.64
Coast Guard Station	0.96	97.9%	45.71
Kendale Complex		85.0%	
Virginia Key	21,640.0	79.3%	to be retained
TOTAL			1,843.54
South District			
South Miami Heights	306.0	92.2%	3,923.08
Cutler Ridge	479.0	86.5%	3,548.15
Bell Aire	180.0	77.8%	810.81
Homestead Air Force Base	318.0	63.7%	876.03
City of Homestead	222.0	82.7%	1,283.24
South Dade Labor Camp	35.0	93.9%	573.77
Redland Labor Camp	23.0	90.6%	244.68
Leisure City	76.0	87.8%	622.95

Table 5[a] (Continued)

	Load	Level of efficiency	BOD inflow
Blue Lake Trailer Park	1.19	98.0%	59.50
Medley Mobile Park	.25	95.9%	6.10
Saratoga Springs Apt.	8.24	52.2%	17.24
79th St. Shopping Center	92.80		
American Hospital Supply	1.30	8.8%	1.19
Miami Springs High School	11.00	90.2%	119.64
Country Club Garden Apt.	.63	98.5%	42.00
Lil' Abner Trailer Park	32.00	84.1%	201.26
Pan American Hospital	2	97.8%	90.91
Community Utilities	230	94.4%	4107.14
Peninsular Utilities	502	89.5%	4780.95
Southern Est.	373	76.1%	1560.67
Westwood Lakes	939	85.0%	6260.0
Westchester Hosp.	1.82	97.8%	82.73
Goldberg Apts.	.71	96.0%	17.75
Ludlum Plaza Apts.	.41	99.0%	41.00

Table 5[a](Continued)

	Load	Level of efficiency	BOD inflow
Camp Matecumbe	2.10	94.5%	38.18
Casa Grande Apts.	1.07	96.4%	29.72
El Rancho Apts.	1.43	96.5%	40.86
Naval Air Station		31.6%	
Redlands Mobile Home	2.18	95.2%	45.42
Helman Ct. Apts.	4.98	96.7%	150.91
Sweden House	2.92	72.2%	105.03
Steak & Brew Rest-aurant	1.29	99.2%	16.13
Sea Glades Motel		82.7%	
North Miami	722.0	90.0%	to be retained
Sunny Isles	1,804.0	90.0%	to be retained
TOTAL			29,697.04

TABLE 6[a]

COST OF 90% REMOVAL EFFICIENCY - PART TWO: DOLLARS PER POUND

	BOD inflow	Lbs. BOD to achieve 85% removal efficiency times relevant cost data	Lbs. BOD to achieve an additional 5% efficiency times relevant cost data	Total (sum of preceeding columns)
North district	(80 mgd plant to be constructed, relevant cost data for secondary treatment: $.0572, for tertiary treatment: $1.526)			
	14,216.76	$ 691.22	$1,084.74	$1,775.97
Central district	(60 mgd plant to be constructed, relevant cost data for secondary treatment: $.0592, for tertiary treatment: $1.637)			
	1,843.54	$ 92.77	$ 150.09	$ 242.86
South district	(50 mgd plant to be constructed, relevant cost data for secondary treatment: $.0602, for tertiary treatment: $1.684)			
	29,697.04	$1,519.60	$2,500.49	$4,020.09
Total		$2,303.59	$3,735.32	$6,038.92

(85% of 14,216.76) need to be removed. This figure times \$.0572/day, which is the cost of removing one pound BOD at a treatment plant of 80 mgd capacity (see Table 4[a]), yields \$691.22/day. The cost of achieving 90% efficiency is found similarly, since the tertiary process is in addition to the secondary process. Then the two are summed.

The total for the County is \$6,038.92 per day, \$2,303.59 secondary, and \$3,735.32 tertiary treatment. This is a cost of \$2,204,205.80 per year to close all municipal sewerage plants and build three large plants that will achieve 90% removal efficiency. Here can be noted the large difference in the cost of using a tertiary process from that of using only a secondary process. The present value[27] of \$2,204,205.80 at 6% over 28 years is \$28,177,465.

Provision in the municipal sewerage system for treatment of the 7,240 lbs/day BOD discharged by industry must be made as well. The discharges of industries located in the central sewerage district amount to 2,419 lbs/day BOD; the remainder, or 4,821 lbs. BOD will flow to the northern district. Cost calculation for treating this sewage was based on the size plant to be constructed in each district, according to the Water Quality Management Plan.

In the north, 4,821 lbs/day will be treated at a plant of 80 mgd capacity at a cost of \$.0572/lb. for 85% removal and \$1.526/lb. for removal of the additional 5%, making it \$234.39/day or \$85,552.35/year for secondary treatment, and \$317.84/day or \$134,262.44/year for tertiary treatment.

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[27] Discounted by $\sum_{i=1}^{28} 1/(1+6\%)^i$

In the central district, 2,419 lbs/day BOD will be treated at a cost of \$.0592/lb. for 85% removal and \$1.637 for removal of the additional 5%, making it \$116,694.15/year.

The cost of incorporating the unsewered population into sewerage districts was found in the same manner as in the text, amounting to \$17,288,600 to \$207,463,200 for hook-ups (estimated at \$100,000,000), and \$331,433,088 for gravity lines and pumping stations.

The equivalent of 59.9 mgd can be expected in total sewage flow from this unsewered population. With figure 3 (from the text) mapped onto a Dade County census tract, it would have been possible to determine the population in need of sewering by sewerage districts, and flows allocated to corresponding plants. However, since the three plants that will be constructed will have similar capacities, costs would vary by only a few dollars/mgd, or by about \$15,300/year less. This figure was built into a cost range, however costs were determined for the total flow at a 60 mgd plant.

To provide facilities will run approximately \$4,959,519 to \$4,974,819, or \$66,488,800 to \$66,693,916 in present value: \$79.08/day in capital costs and \$25.71/day in operating costs for secondary treatment, and \$58.58/day in capital costs and \$70.17 in operating costs for tertiary treatment (see Table 4[a]), for every mgd (multiplying by 60) and every day of treatment (multiplying by 365).

Provision must also be made for future sewerage needs. High and low projections of population increase in Dade County for the year 2000 are 2,270,000 and 1,790,000 respectively, from the 1971 estimated total of 1,315,400.

The Dade County Planning Department estimates that 34% of the population will reside in the northern portion of the county, 40.3% in the central portion, and 25.6% in the southern portion. Future sewage flows could have been allocated to treatment plants on this basis, but since it is not known where and of what cpacity future plants will be, (the recommeded plan of the Water Quality Management Plan provides for a plant of 80 mgd capacity to be built in the western portion of the county in 1985), costs were estimated for total sewage flows.

To provide facilities for this increase in population to the year 2000 will require another 47.5 to 95.5 mgd in plant capacity (estimated at 100 gallons/person/day). If we add to this capacity 20 mgd for industrial growth (to double industrial water use by the year 2000), costs for plant construction and operation range from $5,606,017 (estimated for a plant of 60 mgd capacity) to $8,790,260 (estimated for a plant of 100 mgd capacity). The present values[28] of these figures are $28,155,099 to $44,147,323.

The cost of additional gravity lines, pumping stations, and hook-ups in growth areas of the County was estimated as in the text: at a total cost of $460,437,000 or $215,852,866 in present value.[29]

Connell Associates, Inc. estimate $30,289,200 (including 20% for contingencies, engineering, administration, etc.) to extend the Virginia Key outfall, build a new ocean outfall parallel to the existing North Dade outfall,

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[28] Discounted at $\sum_{13}^{28} 1/(1+6\%)^i$

[29] Discounted at $1/(1+6\%)^{13}$

TABLE 7a

ESTIMATES OF CONNELL ASSOCIATES, INC. FOR TRANSMISSION LINES AND OUTFALLS

PROJECT DESCRIPTION	CONSTRUCTION COST
New Ocean Outfall and Pumping Station to parallel existing North Dade Outfall. Combined outfalls designed for maximum average flow and 100 MGD.	$ 8,840,000
Transmission Line and Pumping Station from Sunny Isles and Eastern Shores Treatment Plants. Designed for flows from zones 104 and 105.	$ 730,000
Transmission Line and Pumping Station to serve zone 109, Biscayne Bay and El Portal areas and to connect to North Dade Interceptor.	$ 1,023,000
Transmission Line and Pumping Station from zones 107, 208, and 321 to existing North Dade Preliminary Treatment Plant.	$ 1,986,000
East Hialeah Connecting Main & Pumping Station	$ 1,228,000
Transmission Line and Pumping Station from zone 201 to present North Dade Interceptor. Designed to carry wastewater from zone 202 after 1980.	$ 4,234,000
New North Interceptor Part A, and Pumping Station. Connect project 10, zone 101, and North Miami Beach initially to existing North Dade Outfall, then to new North Dade Regional Wastewater Treatment Plant.	$ 5,434,000
New North Interceptor, Part B, and Pumping Station. Connects project 9 and zones 201 - 208, 209 - 211 to North Dade Regional Wastewater Treatment Plant thereby relieving the existing North Dade Interceptor.	$ 6,654,000
Transmission Line and Pumping Station to serve the Riverdale Treatment Plant and the western half of Zone 206.	$ 646,000

TABLE 7[a](CONTINUED)

PROJECT DESCRIPTION	CONSTRUCTION COST
Transmission Line and Pumping Station to serve the Andover Treatment Plant and the Eastern portion of zone 206.	$ 620,000
Transmission Line and Pumping Station to serve zone 110.	$ 865,000
Transmission Line and Pumping Station to serve Golden Isles Treatment Plant and zone 103.	$ 1,202,000
Extend existing Virginia Key Outfall.	$ 8,333,000
Outfall pump station for Virginia Key Treatment Plant.	$ 860,000
Transmission Line and Pumping Station from Miami Beach to Virginia Key Wastewater Treatment Plant.	$ 7,208,000
Transmission Line to relieve eastern section to West Dade Interceptor at 37th Avenue.	$ 2,184,000
West Miami Transmission Line and Pumping Station to serve zones 314 and 320.	$ 2,778,000
Cutler Ridge Interceptor and Pumping Station Phase II.	$ 553,000
Cutler Ridge Interceptor and Pumping Station Phase I. To serve zone 407 and connect zone 411 to the South Dade Wastewater Treatment Plant.	$ 1,417,000
Homestead Region Transmission Line and Pumping Station, to connect projects 23 and 24 to South Dade Treatment Plant.	$ 2,368,000
Homestead Air Force Base Transmission Line and Pumping Station to serve zone 401 and 408.	$ 888,000

TABLE 7a (CONTINUED)

PROJECT DESCRIPTION	CONSTRUCTION COST
Homestead - Florida City Transmission Line and Pumping Station to serve zone 401, 403, and 409.	$ 4,465,000
SW 137th Avenue Transmission Line from Kendall Lake Treatment Plant Phase I.	$ 797,000
SW 137th Avenue Transmission Line and Pumping Stations Phase I.	$ 10,881,000
Kendall Lakes Transmission Line and Pumping Stations.	$ 4,434,000
Allowance for Miscellaneous Sites and Easements.	$ 1,873,000
Allowance of 20% for contingencies, engineering, inspection and administration.	$ 16,125,600

provide a transmission line from Miami Beach to the Virginia Key treatment plant,[30] and provide pumping stations for these, (see table 7 a).

Also, $2,300,000 is currently budgeted by the Dade County Port Authority for construction of industrial waste collection and pre-treatment facilities at the Miami International Airport.[31]

Costs for industrial pre-treatment were estimated as in the text, at $562,500.

Summary

Table 8a summarizes the total cost of the pollution abatement program and derives its present value. It must be stressed that these are only approximate values. The assumptions made in developing these estimates are especially strong.

Costs for treating municipal wastes and industrial effluents were based on a cost per pound BOD removed. Total flows from waste sources were first found and allocated to three large treatment plants according to an engineering design developed by Connell Associates for the Master Plan of Sanitary Sewage.

Costs for treating these sewage flows were estimated according to the cost per pound removed however, not according to mgd flow.

In estimating the need in treatment facilities for the unsewered

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[30] The Miami Beach outfall presently discharges untreated sewage.

[31] Communication of the Dade County Port Authority.

TABLE 8 [a]

PRESENT VALUE OF TOTAL COSTS TO DADE COUNTY OF POLLUTION ABATEMENT

New facilities for existing sewage flow:		
North district:	\$ 648,229.05/year	
Central district:	88,643.90/year	
South district:	1,467,332.85/year	
Total:	2,204,205.80/year	
Discounted at:	$\sum_{1}^{28} \frac{1}{(1+6\%)^i}$	\$ 28,177,465
Facilities for industrial, pre-treated, effluents:		
North district:	\$ 219,814.79/year	
Central district:	116,694.15/year	
Total:	336,508.94/year	
Discounted at:	$\sum_{1}^{28} \frac{1}{(1+6\%)^i}$	\$ 4,301,762
Provision for the unsewered population:		
Transmission lines:	\$66,464,400	
Gravity lines:	331,433,088	
Hook-ups:	100,000,000	\$497,897,488 (undisc.)
Treatment plant facilities:		\$ 66,488,800 to \$ 66,693,916
Discounted at:	$\sum_{1}^{28} \frac{1}{(1+6\%)^i}$	
Provision for the future:		
Treatment plant facilities:		
Discounted at:	$\sum_{13}^{28} \frac{1}{(1+6\%)^i}$	\$ 28,155,099 to \$ 44,147,323
Gravity lines and hook-ups:	\$306,236,640	
Discounted at:	$\frac{1}{(1+6\%)^{13}}$	\$215,852,866
Industrial pre-treatment:	(undiscounted)	\$ 562,500
Waste Collection system, Miami airport:	(undiscounted)	\$ 2,300,000
Outfalls:	(undiscounted)	\$ 30,289,200
TOTAL:		\$874,025,180 to \$890,222,520

population flows were not allocated between plants, an estimate was only made of the discrepancy resulting in estimating costs for total sewage flow.

The total estimate ($874 million to $890 million) should be compared to the cost of plan G-1 ($1,005 million) since the cost of transmission lines, outfalls, and the locations and capacities of treatment plants were based on this plan. First, however, an adjustment in the cost of plan G-1 must be made. The cost of providing gravity mains, pumping stations, and hook-ups, which were discounted by $1/(1+r)^7$ for plan G-1, were left undiscounted here. After adjustment for this difference, the cost of plan G-1 becomes $1,150 million.

The costs developed in this appendix are lower than this figure because costs/mgd are lower than those of Connell Associates.

Appendix II - THEORETICAL CONSIDERATIONS

Figure 6 depicts schematically the way in which water quality is a function of both the physical-biological system and man-induced factors. Water quality can be directly improved by the reduction of waste emissions or by the modification of wastes after their generation and emission.

Methods for reducing waste emissions include: changing the type of raw material inputs, changing the production process, changing the product output, or in-plant recirculation of water. Following generation, on the other hand, waste materials may be recovered, used in the production of by-products or re-used following treatment.[32] These are often very real alternatives although they may not be applicable in a particular industry at a particular time.

Methods for making more efficient use of natural assimilative capacity include: regulated discharge of waste to allow recovery, and use of multiple outlets from reservoirs for the same purpose. Methods for improving assimilative capacity include: reaeration of streams, addition of dilution water, and reservoir mixing.[33]

Stated simply, water quality can be effectively controlled and there are alternative available to a regional planning body. However, to provide a basis for a comprehensive water quality management program, a great deal of information must be compiled and its implications assessed. The input-output

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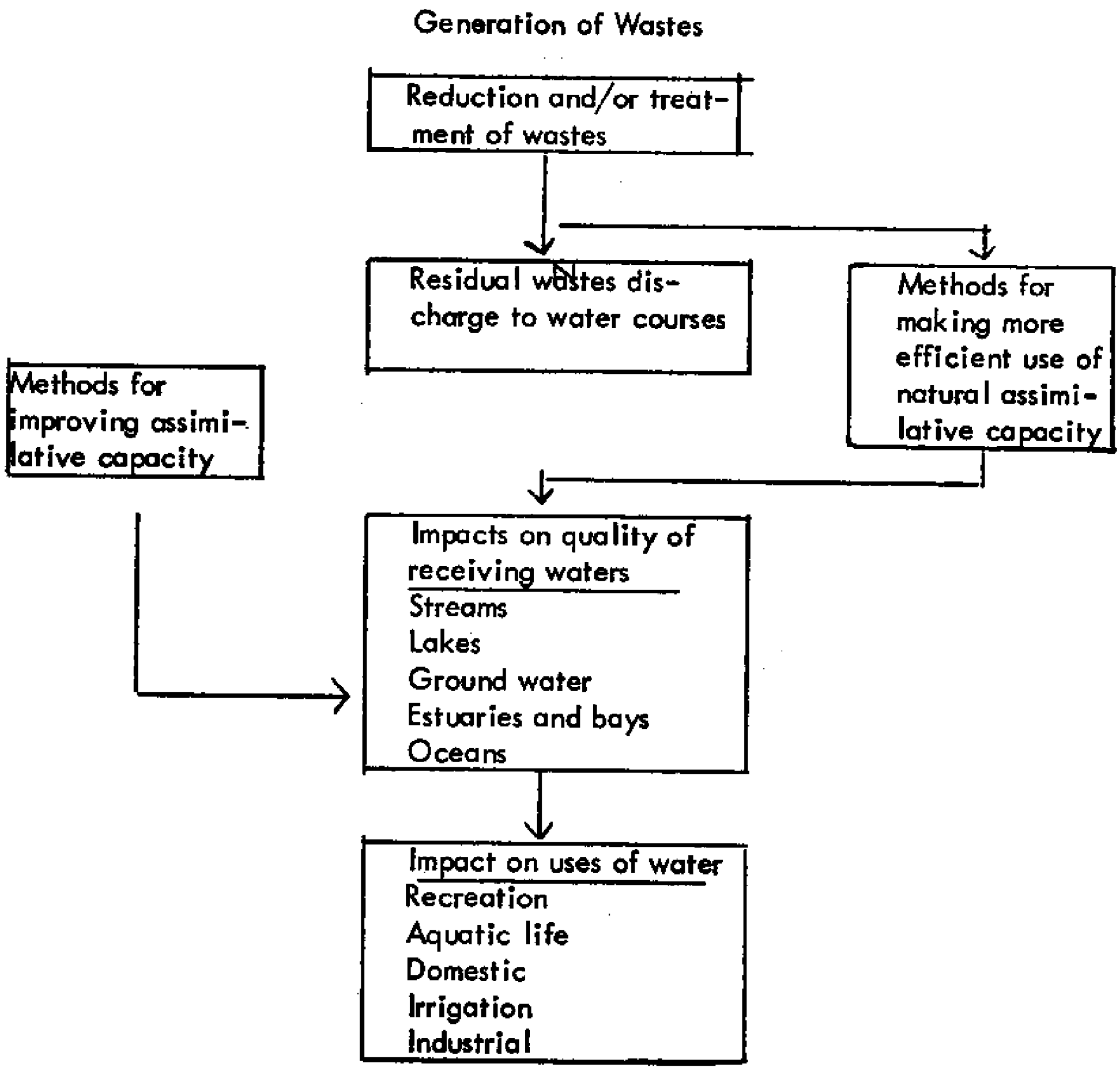
[32] Allen Kneese and Blair Bower, Managing Water Quality: Economics, Technology, Institutions (Baltimore: John Hopkins Press, 1968), p. 42

[33] Ibid, p. 42.

FIGURE 6



Source: Allen Kneese and Blair Bower, Managing Water Qualtiy: Economics, Technology, Institutions (Baltimore: Johns Hopkins Press, 1968), p. 14.

approach is one way of accomplishing this; it provides a comprehensive description of a regional economy and its interactions with the environment.

Input-Output Analysis

Professor Wassily Leontif has only recently discussed the adoption of his basic input-output model in analysis of repercussions of economic activity on the environment.[34] Isard has suggested the input-output approach to study economical-ecological linkages also.[35] And Ayres and Kneese[36] have used the input-output technique to trace "residual" flows between resources, commodities, final demand, and "unwanted inputs," as part of a general equilibrium model. Residuals being either rubbish, harmful gases, or wastes, and unwanted inputs being inadvertent use of pollutants in the production or consumption processes.

The input-output technique is a method used to focus on the interdependencies among the various sectors of the economy: agriculture, industry, manufacturing, and services. The underlying assumption is that inputs into each sector of the economy from the other sectors are a stable and linear function of

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[34] Wassily Leontif, "Environmental Repercussions and the Economic Structure: An input-output approach" Review of Economic Statistics (1970), pp. 262-271.

[35] Walter Isard et al., "On the Linkage of Socio-Economic and Ecologic Systems" Papers and Proceedings of the Regional Science Foundation, XXI (1968), pp. 80-99, and Walter Isard et al., Ecologic-Economic Analysis for Regional Development (N.Y.: The Free Press, 1972)

[36] Ayres and Kneese, "Production, Consumption, and Externalities" American Economic Review, XXXXXIX (1969), pp. 282-297.

the output of that sector, with fixed coefficients of production. (For example, some subset of the agricultural sector could have the following input structure: $10 million worth of agricultural inputs, it could be seeds, $2 million worth of industrial inputs, say chemicals and fertilizers, and $3 million worth of service inputs, probably marketing services. Then, if it doubled its output, it would double its inputs, using $2 million worth or seeds, $4 million worth of chemicals and fertilizers, etc.)

Needless to say, some processes, may not be linear. This is especially true of ecological processes. Nevertheless, systematic description of variables and magnitudes as they exist at a point in time can be made.

Following Hite and Laurent,[37] the data needed for a regional implementation of the input-output technique can be tabulated in two tables. One table includes the gross sales from one sector of the economy to every other sector, based on calendar transactions; the other relates the inflow from the environment, i.e. natural resource inputs, to the residual outflow to the environment, i.e. waste emissions, for each sales dollar of each of the economic sectors.

The multiplication of the elements in one table, by the elements in the other table yields a third, very different, table estimating the direct and indirect changes, per dollar sales, in the use of, or in the discharge to, the environment. For example, one row in this table might relate the change in the

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[37] James Hite and Eugene Laurent, "Empirical Study of Economic-Ecologic Linkages in a Coastal Area," Water Resources Research, VII, No.5(1971)

amount of suspended solids to be expected from each sector (agriculture in general, the production of oranges, or milk, canning, or soft drink manufacture) per dollar increase in sales, and another row might be the amount of water needed by each sector for a dollar increase in its sales.

To arrive at approximations of the trade offs between economic growth and environmental quality for each sector, Hite and Laurent divide this last table by a "value added coefficient" or a "local income multiplier" which Leontif tells us would represent the cost of labor and capital, profits, taxes, and other costs incurred by the industry or received by the community as income. This final table can be interpreted as an estimate of the repercussions on the environment of a dollar's increase in income in each sector of the economy. The output level of pollutants can then be effectively traced to an increase in demand in one or more sectors, or to a technological change in production or pollution control. Also the effects on the environment of increasing demand for goods and services or of a technological change can be predicted.

By establishing an "anti pollution" sector as suggested by Leontif, (such as the Pollution Control Board), its coefficients in the final table could effectively estimate how much its level of operation would have to vary with changes in the level of pollution.

The approach taken by Isard et al.[38] is to derive ecological interrelation coefficients using variables such as nutrients and organisms used as

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[38] Walter Isard et al., Ecologic-Economic Analysis for Regional Development (N.Y.: The Free Press, 1972)

food by a fishery resource. The method is very comprehensive and it is very clear in the derivation of coefficients, although biological coefficients are built upon oversimplified assumptions.

An example used is the production of winter flounder. The food requirements, in pounds, of algae, annelida, mollusk tips, crustaceans, (all bottom-dwelling organisms), and other small amounts of organic food matter for the production of one million pounds of winter flounder are first established.

One million pounds of winter flounder requires approximately ten times its weight in food inputs as follows:

3.36 million pounds of annelida,

2.73 million pounds of algae,

2.30 million pounds of mollusca,

.71 million pounds of crustacea,

.90 million pounds of other miscellaneous food, and

.04 million acres of bay or estuary water area.

Annelida, mollusca, and crustacea in turn require detritus as food at a ratio of approximately 10 to 1:

the 3.36 million pounds of annelida require 33.6 million pounds of detritus,

the 2.30 million pounds of mollusca require 23 million pounds of detritus,

and the .71 million pounds of crustacea require 7.1 million pounds of detritus.

The area requirements are as follows:

3.36 million pounds of annelida require 25,000 acres of muddy and sandy bottom (1 million pounds of annelida require .007550 million acres), 2.30 million pounds of mollusca require 5,200 acres of muddy and sandy bottom (1 million pounds of mollusca require .002265 million acres),

.71 million pounds of crustacea require 5,400 acres of muddy and sandy bottom (1 million pounds of crustacea require .007550 million acres),

2.73 million pounds of algae require 22 acres of intertidal and subtidal shoal water (1 million pounds of algae require .000008 acres),

.90 of other miscellaneous plants require 7.2 acres of muddy and sandy bottom (1 million pounds of plants require .000008 million acres).

Production requirements for cod, soft-shelled clams, phytoplankton and any other product of the ecosystem can be similarly described from its food chain.

To place this information into the input-output framework Isard develops a classification system in the manner of the Standard Industrial Classification (S.I.C.) System (Bureau of the Budget) used for economic activities.

The first major division is that between land (L) and marine (M) processes. All designations, both economic and ecologic begin with either an L or an M, followed then by an X for the specifically ecologic processes and products. Particular areas of the land or marine environment follow the designation by a superscript. For example, the Biscayne Bay area would be designated, M^B.

A number following the letter designation indicates the environmental heading. Under hydrology, the Water Pollution Classification (WPC) Code is used to describe water intake and discharge activities. The economic headings are agriculture, manufacturing, services, and government.

This information is then placed in an interrelations table, relating outputs of the environment and the economy to their inputs. Such a table is extremely useful for systematic description and comprehensive planning, although only portions of the table would be employed according to the problem being investigated.

If major water polluting industries increased production, for example, the higher BOD coefficient would result in a DO quality inconsistent with any swimming activity. The inconsistency must be resolved by either zero level swimming, lower level production, or treatment of pollutants.

Land requirements included in the table can reveal inconsistencies in the same way.

The inclusion of crustaceans, etc. as inputs into the winter flounder production would require that other processes must be going on to produce crustaceans, algae, and other food for winter flounder.

With this kind of detailed information of a regional economy, complete study can be made of the impact of major activities on an area and also for least cost (including ecologic cost) site location.

Appendix III - PRESENT VALUE

The equation for the present value of a stream of costs is:

$$PVC = \sum_{i=1}^{n} \frac{C_i}{(1+r)^i}$$

where C_i is the cost for the ith year of life of the project, n is the length of life, and r is the rate of discount. For example, if the cost of a certain project in its fifth year of operation is $2,500, and the interest rate is 5%, then dividing $2,500 by $(1.05)^5$ or (1.2762) will result in the present value of the $2,500 five years from now. This amount is $1,958. Looked at another way, if $1,958 is put in a savings account that earns 5%, at the end of five years it will be worth $2,500. This why on page 32 the capital outlay for i years in the future was divided by $1/(1+r)^i$.

The present value equation is just the sumof this discounted costs over the life of the project. By making use of it, it is possible to place a single value of a multi-yeared project. This makes it possible to compare this value with the benefits of building the project and also with the present value of other projects.

If all the costs are the same then the above equation can be changed to:

$$PVC = \left[\sum_{i=1}^{n} \frac{1}{(1+r)^i}\right] C.$$

This is where the multiplier for the operating costs on page 34 comes from.

ec

July 12, 1972

R. M. Sampedro
6475 S.W. 92nd Street
Miami, Florida

Sir:

In reference to your letter of June 25, 1972 to the Pepsi-Cola Bottling Company, I am pleased to submit the following as the best available information which we have to answer your question.

As a result of actions to abate alleged pollution emanating from our plant at 7777 N.W. 41 street, Pepsi-Cola Bottling Company made an interim investment of $130,000. These monies were invested to remove from the Dressles Dairy Canal all discharges which leave the plant.

There presently exists a disagreement with the Pollution Control authorities as wether or not pretreatment of our wastes is required. If pretreatment is imposed the expected first cost of the devices to perform this pretreatment will run to $150,000 with a monthly operating cost of $800 to $1,000.

I hope the above satisfactorly responds to your inquiry. If further information is required please feel free to write and I will attempt to oblige.

Very truly yours,

Paul Leach

Paul William Leach,
President

FARM STORES

Palmetto Expressway at Northwest 58th Street · Miami, Florida

Executive Offices

June 29, 1972

Mr. R. M. Sampedro
6475 Southwest 92 Street
Miami, Florida

Dear Mr. Sampedro:

I am not exactly sure as to what you desire in the way of information regarding sewage treatment as it pertains to Farm Stores. However, I will give answers to what I think is required.

Approximately five years ago, Farm Stores added to its sewer system and at present our sewage treatment facilities are an investment in the neighborhood of $375, 000. This is a complete treatment plant and while the liquid affluent is discharged into an inland canal, it is pure enough to be used as drinking water. We are hoping that it will be possible for us to connect to the Dade County Sewer System sometime in the year 1972-73. Our estimate for this project is an additional $50, 000 for connection.

I trust that this is the information you desire.

Sincerely,

Alan S. Fogg
Executive Vice President
FARM STORES, INC.

ASF/hl

NORTHEAST

150 S.E. SECOND AVENUE/MIAMI, FLA. 33131/305-373-4736

July 14, 1972

Mr. R. M. Sampedro
6475 S. W. 92 Street
Miami, Florida

Dear Mr. Sampedro:

It was not our purpose to ignore your letter of June 25 concerning the benefit-cost analysis of the abatement of pollution of Dade County's inland canal system.

The facts are that Northeast Airlines is being merged into Delta at the moment, and we are all very much involved in completing these arrangements. Therefore, I must beg off the project and extend my best wishes while at the same time failing to make a contribution.

We hope that you will understand.

Sincerely,

E H Bishop

Edwin H. Bishop
Vice President
Civic Affairs

EHB/maw

Cott Bottling Company
OF FLORIDA, INC.

BOTTLERS OF Cott QUALITY BEVERAGES
A NATIONAL INDUSTRIES COMPANY

7130 NORTHWEST 35TH AVENUE
MIAMI, FLORIDA 33147

693-1210

June 29, 1972

R. M. Sampedro
6475 S. W. 92nd Street
Miami, Florida

Dear Sir:

Thank you for your letter of June 25th.

Although we would be most anxious to help you with your research, we are at the present time conducting an in-depth analysis of our own operation to determine any contribution we can make to the abatement of polution of Dade County's waters and the resulting costs, but at the present time we have no figures we can give you.

Very truly yours,

COTT BOTTLING CO. OF FLA., INC.

S. H. Huberman

S. H. Huberman, President

SHH:am

DADE COUNTY PORT AUTHORITY

MIAMI INTERNATIONAL AIRPORT

MIAMI FLORIDA 33159

Executive Offices
TELEPHONE 634–1511

July 14, 1972

Mr. R. M. Sampedro
6475 S.W. 92 St.
Miami, Florida

Dear Mr. Sampedro:

In reply to your letter of June 25, 1972, you are advised that $2,300,000 is currently budgeted by the Dade County Port Authority for construction of industrial waste collection and pre-treatment facilities at Miami International Airport.

Very truly yours,

DADE COUNTY PORT AUTHORITY

CWMauch

C. W. Mauch, Chief
Operations & Environment

CWM:rs

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